RAP-M
Rapid Assessment, Point Method

&

BATHMASTER
Bathymetric Depth Mapping

Erosion and Sediment
Inventory Procedures
Illinois
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NRCS Natural Resources Conservation Service

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Introduction

This booklet outlines the Rapid Assessment, Point Method (RAP-M) to capture erosion and sediment information on a watershed scale and Bathymetric mapping methods to calculate reservoir sediment volumes for use by NRCS/ SWCD field personnel. Use of these procedures does not guarantee the exact determination of erosion and sediment information in any given area. However, these procedures will provide the user with a tool that produces a reasonable estimate of erosion and sediment in a watershed.

RAP-M is designed for use on watersheds. It is not site-specific and becomes less reliable when applied to units smaller than an entire watershed. This procedure is not meant to be used as a regulatory device. For more information on RAP-M contact:

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Bathymetric mapping, BATHMASTER, is designed to gather current sedimentation information for use by local communities and landowners as a resource planning tool and as a data collection device for the National Cooperative Sedimentation Survey. This procedure is not to replace surveys conducted by private engineering firms. For more information on BATHMASTER, contact:

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Rapid Assessment, Point Method

Inventory and Evaluation of Erosion and Sedimentation for Illinois

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12/00

Introduction

Objective of this Booklet

The objective of this document is to provide guidance and a simplified procedure for inventory and evaluation of erosion and sedimentation within small watersheds. It is intended for use by Natural Resources Conservation Service (NRCS) and Soil and Water Conservation District (SWCD) field staffs. This guide summarizes and revises several earlier and more generalized attempts to estimate total erosion and sedimentation within watersheds.

Purpose of RAP-M

RAP-M is an assessment used by NRCS/SWCD field personnel since the mid-1990's to produce an estimate of the average annual rates of erosion and sedimentation by sampling small areas and expanding the results to illustrate the condition of the entire watershed. This procedure was prepared for local use to determine the magnitude of the erosion and sediment problem and to estimate additional technical assistance needs. The results of this procedure assist in assigning priorities, measuring the expected effects of land treatment, and evaluating the effectiveness of applied conservation practices. RAP-M can identify land treatment and structural needs on many watersheds where erosion and sedimentation has been determined to be a water quality problem.

NOTE: While this procedure was prepared for use on "lake" watersheds, it is also applicable to watersheds without a reservoir.

Overview of the Procedure

This procedure is a scaled-down version of that used by the NRCS Planning and Design Team to inventory and evaluate PL-566 Watershed Protection projects. It does not include detailed inventories and evaluation of environmental, hydraulic, and economic parameters. This procedure, when used appropriately, produces a good estimate of the watershed sediment problem.

RAP-M requires both field evaluations and in-office calculations to produce an estimate of the average annual rate of erosion and sedimentation. This includes sample area selection, slope and watershed type determination, channel and erosion measurements, and tillage system and ground cover determination. This information is then used to calculate an estimated average annual rate of erosion and sedimentation. (See fig. 19 for an outline of the RAP-M procedure.)

Time Needs

Plan to spend roughly one day of work per 1,500 acres of watershed to complete all field and office work associated with this procedure. This time frame relates to the smaller watersheds that are typical of Illinois NRCS projects.

Personnel Needs

This procedure is designed for use by NRCS/SWCD personnel who are familiar with field operations, tillage systems, and residue cover. A RAP-M erosion and sedimentation inventory and evaluation should be planned with the Field Operations District (FOD) Resource Planning Specialist who can organize any necessary assistance. The FOD Resource Planner also coordinates the efforts of field personnel with the assistance of the NRCS Planning and Design Team in the processing of data to ensure the consistency of erosion and sediment inventories statewide.

Equipment Needs

No special equipment is needed to complete the RAP-M inventory and evaluation. Be prepared to refer to the NRCS Field Office Technical Guide (FOTG).

Programs

This procedure is applicable to all conservation programs and should be used to make the initial evaluation of erosion and sedimentation for all special projects. The Field Office/SWCD can use this procedure to identify and target needs in high priority areas for on-going conservation programs. It can also be used to evaluate Priority Areas for EQIP projects and for possible PL-566 considerations.

Limitations

In order to use the procedure most effectively, it is important to keep in mind certain limitations. This system is flexible and can be adjusted to fit all local conditions and situations, but is most accurate when used on *small* watersheds. RAP-M has more limited practical use on large watersheds where field sampling becomes less concentrated, resulting in less reliable and less applicable data. RAP-M will not identify all severely eroding streambanks and is not to be used at the exclusion of more precise, measured data that is readily available. RAP-M is not a monitoring system or regulatory device in any way, shape or form.

RAP-M is, however, accurate and reliable when used for *planning purposes*, producing soft data that can then be used to estimate hard numbers.

What RAP-M *IS*

- √ Snapshot of current conditions in a watershed
- √ Estimate based on actual measurements and field evaluations
- √ Way to evaluate and quantify natural conditions
- √ An average annual rate of erosion and sedimentation
- √ Accurate and reliable when used for planning purposes
- √ Flexible system that can be adjusted to fit local conditions
- √ Soft data that can be used to estimate hard numbers
- √ Method of using statistics to compute reliable projections
- √ Developed for small watersheds

What RAP-M *IS NOT*

- x Not a monitoring system
- x Not hard data
- x Not to be used at the exclusion of more precise, measured data
- x Not site-specific
- x Not as reliable or applicable on large watersheds

Pre-Field Procedure

1. Project Base Map Preparation

Assemble the most current aerial photos, soil maps, and quadrangle maps of the watershed. It is desirable to have the maps at the same scale (either 4 inches = 1 mile or at the scale of the quadrangle maps) for ease in preparing a composite base map. The preparation of this composite map and future work can be simplified by using a mylar overlay to trace on. The increasing use of Geographic Information Systems (GIS) offers tremendous potential for future application. Using a GIS can increase the accuracy of all map measurements and help precisely locate important sites in the watershed.

2. Delineation of Land Use

Place the mylar overlay on top of the aerial photo and outline the major land uses in the watershed or any applicable subwatersheds. Capture areas of water, flat and sloping cropland, grass land, woodland, urban land, and any surface mined areas.

Cropland Slope Delineation: Using the land use overlay and the soils map, delineate any major areas of soils which are primarily A slopes. These have relatively low sheet and rill erosion rates.

Types of Watersheds: Sample selection will be based primarily on slope and land use delineations. In Illinois, there are three general types of watersheds with different topographic features. The inventory and evaluation of these types of watersheds should be performed somewhat differently. These three types of watersheds are:

Type A Those watersheds which have large areas of primarily A slope land. These areas often can be delineated as a separate unit from the more sloping areas. The A slope cropland is generally not a major problem in regard to erosion and sedimentation. The remaining B slope-and-greater land is then the major area of concern for inventory.

Type B Those watersheds with characteristics and features intermediate between Type A and Type C.

Type C Those watersheds that have rolling or steeply sloping topography with the slopes either interspersed throughout the watershed or occurring primarily along the major drainageways. Generally, these types have a low percentage of A slopes. If present, they are usually on the ridgetops only.

Measurement of Land Use Area: Measure the acreage of each delineated land use on the composite overlay map. Also measure the A slope area and B slope-and-greater area. Dot counting and estimating acreage are faster but, of course, less accurate than using a planimeter. Roads should only be counted if the area is extensive (i.e., in an urban area). If roads are measured, use an average width of 50-60 feet. (See fig.

3. Inventory Area Determination

This step is most critical and good judgment is necessary to select sample areas that are truly representative of the watershed. A suggested size of 160 acres for each sample unit will allow evaluation of several fields at each field stop. Selection of areas to be sampled and the number of samples should reflect a weighted percentage of the area based on drainage patterns, topography, soils, and cropping patterns. Example: if 75% of the watershed contains similar soils, slopes, and cropping patterns, then 75% of the acreage sample should be in this area. If only a small but significant part of the watershed contains gullies, this portion, no matter how small, still needs to be sampled to fully characterize the gully erosion situation.

Sampling Guidelines: Recommendations for this procedure are to inventory about 30 percent of a 4,000 acre or smaller area and about 15 percent for an area of 20,000 acres. Thus, for each 1,000 acre increase in size for watersheds over 4,000 acres in size, reduce inventory area by 1 percent (from the 30 percent). For watersheds exceeding 30,000 acres in size, use a 10 percent sample density. For example, using 160-acre sampling units in a 10,000 acre watershed, approximately fifteen (15) 160-acre units would need to be evaluated. [10,000 X (30%-6%) / 160 = 15] These sample units should also be selected "randomly." To do this, use random number tables or simply choose random numbers that would correspond to consecutively numbered quarter sections delineated on a quadrangle map.

In-Field Erosion Determination

Sheet and Rill Erosion

Within these sample units, calculate sheet and rill erosion loss using the Revised Universal Soil Loss Equation (RUSLE). Use the Universal Soil Loss Equation (USLE) for woodlands and urban areas. Obtain a **rate** of average soil loss for each of the major land uses represented. (Use fig. 9-10 for guidance.) On an inventory summary sheet (see example fig. 3), record by slope group (column 1), the acreage of each land use area (column 2). Using the erosion rate calculated above (column 3), compute gross sheet and rill erosion for the current conditions by multiplying column 2 by column 3. Place this value in column 4.

Ephemeral Gully Erosion

Ephemeral gully erosion <u>generally</u> occurs on cropland with B slopes and greater, but unless there is no A slope cropland in the watershed, sampling will need to include some of the A slope land as well. If not, the sampling will be biased toward ephemeral erosion. Normally, the area where concentrated flows occur can be visually distinguished in the field, whether or not a gully is present at the time. It may be difficult to determine where the gully will begin on the upper end, but one can usually determine the lower end of a potential gully from the much decreased slope gradient or stable outlet such as a grassed waterway.

Select the sample quarter-sections within the watershed which are adequate to truly represent the cropland area. Data to be collected for each ephemeral gully in each sample area is:

1) Length of each ephemeral gully,
2) Average slope of each ephemeral gully, and
3) Tillage system used where each gully occurred.

Example Ephemeral Gully Inventory

Pre-Field

1. On the photobase (overlay) map, mark the location and approximate length of each ephemeral gully. Show both existing gullies and also areas where gullies are likely to occur. This could be done in the office with good photos but will also require field observations and verification.

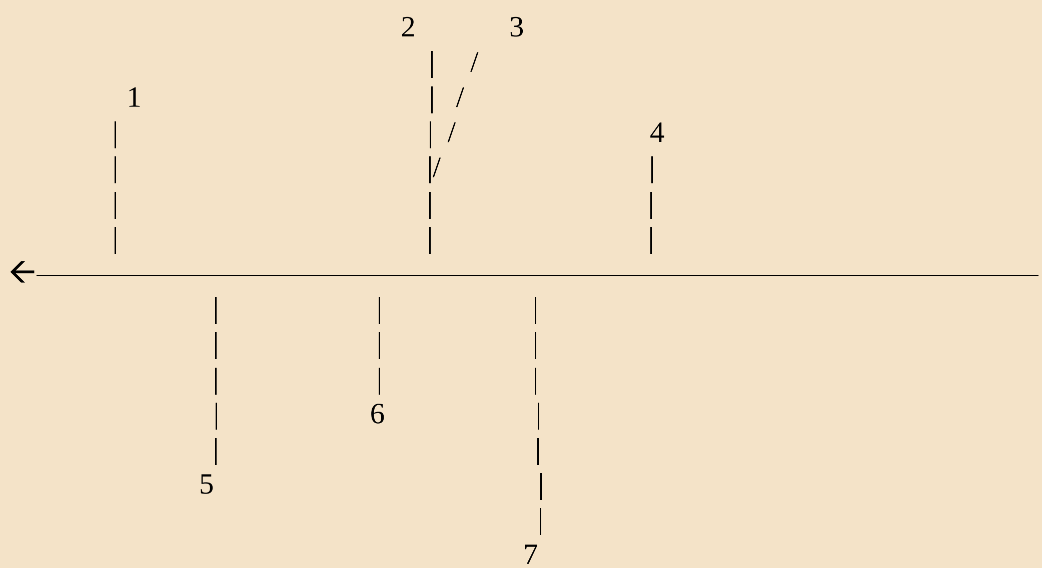
2. From the aerial photo, measure and record the ephemeral gully length.

3. Use the soils map and a working knowledge of soil slopes to estimate the average slope of the ephemeral gully and record.

Field

4. For each ephemeral gully, record the tillage system used in the area where the gully occurs (See sample example area below).

Example Sample Area - 160 acres



Example Ephemeral Gully Inventory

Gully No.	Length	% Slope	Tillage
1	820	3	Chisel
2	550	4	Chisel
3	690	4	Chisel
4	420	3	Chisel
5	520	3	Conv. Plow
6	570	3	Conv. Plow
7	770	2	Conv. Plow

Example Ephemeral Gully Inventory (continued)

Evaluation
The evaluation procedure is in the FOTG (NRCS Field Office Technical Guide) and can be used for reference.

Data Needs:
- √ Computation of ephemeral gully erosion for each sample area.
- √ Expansion factor of sampled area to the total cropland.
- √ Ephemeral gully erosion study data which includes the ephemeral gully erosion equation and Table 1 - Soil Loss Factor By Length, Table 2 - Soil Loss Factor By Percent Slope, and Table 3 - Soil Loss Factor By Fall Tillage.

Ephemeral Gully Erosion Equation:

Erosion (tons) = Mean tillage factor x length factor x slope factor x tillage factor x ephemeral gully length (feet)

a) Erosion = Soil loss in tons from a single voiding
b) Mean tillage factor = A constant 0.069
c) Length factor = See Table 1
d) Slope factor = See Table 2
e) Tillage factor = See Table 3
f) Ephemeral gully length = Length in feet

Table 1 - Soil Loss Factor By Length

Length Feet	Erosion - Tons Per Linear Foot	Length Factor
000-099	0.053	0.72
100-199	0.055	0.74
200-299	0.058	0.78
300-399	0.062	0.84
400-499	0.069	0.93
500-599	0.080	1.08
600-699	0.087	1.18
700-799	0.090	1.22
800-899	0.093	1.26
900-999	0.095	1.28
>1000	0.096	1.30

Table 2 - Soil Loss Factor By Percent Slope

Slope (Percent)	Erosion - Tons Per Linear Foot	Slope Factor
1	0.0750	1.15
2	0.0728	1.12
3	0.0706	1.09
4	0.0684	1.05
5	0.0662	1.02
6	0.0640	0.98
7	0.0618	0.95
8	0.0596	0.92
9	0.0574	0.88
10	0.0550	0.85

Example Ephemeral Gully Inventory (continued)

Table 3 - Soil Loss Factor By Fall Tillage

Fall Tillage	Erosion - Tons Per Linear Foot	Tillage Factor
Moldboard Plow	0.089	1.35
Chisel Plow	0.069	1.04
Untilled	0.041	0.62

Computation of Example Quarter Section:

Gully No.	Tillage Constant	Length Factor	Slope Factor	Tillage Factor	Length (Feet)	Erosion (Tons)
1	0.069	1.26	1.09	1.04	820	81
2	0.069	1.08	1.05	1.04	550	45
3	0.069	1.18	1.05	1.04	690	61
4	0.069	0.93	1.09	1.04	420	30
5	0.069	1.08	1.09	1.35	520	57
6	0.069	1.08	1.09	1.35	570	62
7	0.069	1.22	1.12	1.35	770	98
					4340	434

Total for example sample quarter section = 434 tons

Total the ephemeral erosion from all fifteen of the sample quarter sections. Knowing how much erosion is occurring in the samples, one is able to determine how much ephemeral erosion is occurring on the total cropland. If the sampling has been representative of the total cropland area, then A slope and steeper cropland areas will have been sampled. For this example, assume the total ephemeral erosion from sampling was 2,170 tons.

Expansion of sampled area to the watershed is based on a factor of the total cropland area to the cropland acres sampled:

Cropland area = 7,970 ac.

Sampled area = 160 ac. x 15 = 2,400 acres sampled

Expansion factor = 7,970 / 2,400 = 3.3

Therefore, gross ephemeral gully erosion = 2,170 tons x 3.3 = 7,161. Round up to 7,200 tons. This value now becomes the estimated ephemeral erosion for the entire watershed. Record this value in Column 4 on the summary sheet in the appropriate row (fig. 3).

Channel Erosion and Sediment Procedure

In Illinois, erosion from streambanks, gullies, and roadsides can be a major source of erosion in certain types of watersheds. Sediment yields from these sources can directly enter the stream delivery system. Two procedures, differing in amount of detail and field sampling involved, can be used to arrive at erosion and sediment values for channels.

Note: Recommendations are to use the **Detailed Procedure** for all purposes other than a *first-order estimate* for the watershed planning process. See Level of Detail for Erosion and Sedimentation Studies (fig. 20).

The detailed procedure is much more field-oriented but has higher statistical significance. The procedure is used to sample, measure, and summarize channel erosion and the sediment that it produces. This procedure should be used in conjunction with the sheet, rill, and ephemeral erosion measurements listed above to complete the entire inventory that is necessary in a small to medium-sized watershed. It is assumed that the inventory is conducted for an entire watershed, and that the watershed boundary has been marked on a (or several) USGS quadrangle map. A *channel* is defined as a concentrated flow area greater than 1 foot in depth and 2 feet in width and NOT destroyed by annual tillage operations. A vegetated waterway or other such stabilized conveyance of water, with a W:D ratio of greater than 20:1, is excluded from this definition. Both *gullies* and *streambanks* are included within this definition, as both are definitely channels. However, the distinction between the two is immaterial because the procedure for measurement is essentially the same. For informational purposes, generally a stream carries water on a perennial basis and a gully is more apt to carry only peak flows or intermittent water.

Refer to photos 1-5 for visual examples of the Average Annual Rate of Recession.

Detailed Sampling procedure: To sample a small tract of land, it may be possible to walk ALL the channels to gather data. To sample an entire watershed, this becomes impossible. Therefore, select a small portion of the channels, measure these, and then expand this data to fit the complete watershed. To be statistically accurate, approximately 5 to 20 percent of the channels should be measured, depending on the size of the watershed. The larger the watershed, the smaller the percentage of channels that need to be inventoried.

a. On the quadrangle map(s) set up earlier to show the watershed, delineate the areas that are more steeply sloping, that is, where the lines on the map are closer together. These generally occur along the main drainageways and streams. These are the areas of most interest, since the sampling areas should contain 75% or more of the channels that occur within the entire watershed.

b. Measure or estimate the number of acres in the delineated, sloping area. For example, if the entire watershed is 10,000 acres and by plainimeter, measures 6,000 acres in the sloping part, then a 10 percent sample would be 6,000 times 0.10, or 600 acres. This would give a good estimate as to the amount of erosion and sedimentation produced by the channels.

c. Use of the 160-acre sampling blocks set up for sheet and rill measurements makes the job somewhat easier. So, for the example, 600 divided by 160 equals four (4) of the 160-acre sampling units. Select these four randomly throughout the sloping part of the watershed. These sampling units now need to be inventoried in the field for channel erosion.

d. Select several channels within these units to walk and measure erosion. If there is one main channel, be sure to use it and any major tributaries to it. A good length of channel to choose is 1,300 feet (one-quarter mile) for streambank reaches and 500 to 2,000 feet for gullies. In bluff-type watersheds along the major stream valleys, there may be so many channels that it becomes almost impossible to choose. In these situations, select six or eight channels in a random order, for example skipping every other one. The length of each may be determined by scaling from maps or aerial photos, or by pacing or taping if the channels are relatively short.

e. Use the Channel Inventory Form (figure 6A, form and 6B, example) to complete this procedure. The top part of the form is self-explanatory. The formula used to calculate tons of erosion per year from that channel is also listed at the top of the form. To correctly complete the form, be sure to keep in mind that there is a right and a left side of every channel and that each side might erode at a different rate. Record the starting point as well as the direction travelled when conducting the inventory, either upstream or downstream. Both sides must be recorded. Therefore, to complete the form for a channel of 1,300 feet, for example, the numbers on the channel inventory form should total <u>2,600</u> feet. In the Height column, use only the height of the actively eroding slope segment, NOT the entire cut-bank. For example, where a stream cuts into a steep, upland ridge, often the entire exposed bluff shows signs of slumping or movement. However, on closer inspection, only the lower three to four feet of the entire bank are actually undergoing active erosion by the stream on an average annual basis. The section above this is feeding fresh material down to it, but it is NOT being eroded by the bankfull channel flow. (See fig. 11-16 for additional information on the channel inventory.)

The *lateral recession rate* is taken from the attached chart (fig. 7- 8). This rate is a qualitative way to assess width or thickness of eroding surface on a channel. It is used to estimate an actual quantitative measurement. It is based on actual in-field observations and measurements made by the former MNTC in Lincoln, NE (fig.12). Recession rates of eroding banks for Illinois streams and gullies typically range from 0.05 feet 0.5 feet per year. Refer to photos 1-5 for visual examples. Values in the range of 0.05 feet to 0.40 feet are the most typical in perennial streams and rates of 0.05 feet to 0.3 feet most typical in intermittent flow channels. Stream banks with retreat rates of 1 or more feet per year do occur, but are uncommon and not usually widespread within a given watershed. Apply the rates as uniformly and consistently as you can along both sides of each channel. Remember, these numbers are used to obtain *average annual rates*, not those that occur after a 4-inch rain that washes out a bridge abutment. This is the same principle used with USLE and now RUSLE. Rates in the "Very Severe" category of 0.5+ feet of bank recession per year generally only occur in Illinois on segments of channels scattered throughout steep watersheds. If these rates were applied throughout the entire watershed, so much sediment would be produced that the current stream systems could not move it through; it would pile up as huge sediment bars that would block the actual flow of water. Bottom scour of some channels also occurs in some watersheds. Usually this is not as noticeable or as severe as bank erosion for a given channel. Rates of 0.05 feet to 0.4 feet are typical where the scour is occurring. Include any scour erosion totals with the bank erosion on the Channel Inventory Form. (See fig. 17 for general guidelines.)

For *density*, use a value of 95 pounds per cubic foot for channels eroding through loess and silty alluvium. For those cutting in glacial till, use a value of 110 pounds per cubic foot.

f. A *channel inventory form* should be completed for each selected channel in each of the four (4) 160-acre sampling units. The total of all these forms gives us the estimated channel erosion in our 600-acre sample unit. After walking the channel to measure the length and erosion for each, calculate a RATE of channel erosion per linear foot of channel. Only by walking ALL the channels in each of the 160-acre units, would one know exactly how many feet of channels occur within our 600-acre required sampling unit. If not, then we need to <u>estimate or measure</u> the total number of feet of channels in that 600 acres.

g. Expand the sample area to encompass the entire watershed. If, within the 600-acre sampling unit, 12,000 feet of channels were measured or estimated, then to expand this to the entire 6,000-acre, sloping watershed, simply multiply by 10 to arrive at 120,000 feet of channels in the ENTIRE watershed.

h. In most watersheds, 100 percent of the channel banks are not eroding. Some channel systems may actually be aggrading, or building up. A random, stratified sampling procedure should account for this. Based primarily on field observations, one can verify the percentage of channels that are currently eroding. In the example, which is in a non-bluff area, 120,000 feet multiplied by the rate of 0.035 tons per linear foot equals 4,200 tons of sediment produced by channel erosion.

i. As mentioned earlier, both gully and streambank erosion were considered channel erosion and could be calculated as a combined value as the previous example showed. However, to separate these within a watershed to show differences or to isolate a particularly serious sediment source, then inventory and calculate each separately, following the same procedure. On quadrangle maps, streams can sometimes be separated from gullies by using the solid blue lines. This is especially helpful for those who are not physically familiar with the stream in that part of the watershed.

j. The final step is to determine how much of the sediment that is produced by the channel erosion actually moves into and through the stream system. Use a SEDIMENT DELIVERY RATE (SDR) for this type of erosion and for each of the other types of erosion. This predicts sediment available for transport. If we are dealing only with channel erosion, then the SDR is usually near 100 percent (or 1.0). If material is moved from the wall of the gully or falls off the streambank itself, it is readily available for transport; use a value of 0.90 to 1.0 for this calculation. When channel erosion is due mostly to gullies, use 0.90, but if erosion occurs equally between streams and gullies, use 1.0. This number is multiplied by the total sediment number to arrive at the value of "sediment delivered to the ultimate sink" in the watershed. In our example, 4,200 tons times 0.90 equals 3,780 tons delivered to the sink.

k. This value should then be combined with similar totals for sheet, rill, ephemeral and other types of erosion and sedimentation to give a complete picture of the erosion and sedimentation for the entire watershed.

Note: These detailed inventories should be conducted in their entirety with in-the-field inventories, erosion computation, and the expansion of these results to the watershed by a factor. However, the following procedure provides a *first-order estimate* for the watershed planning process that does not involve the extensive field work and sampling.

Simplified Procedure:

1. Match the *Watershed Characteristics* listed below to those in the inventoried watershed.

2. Refer to Figures 1 & 2 to assist in the watershed type determination.

3. Multiply the calculated gross sheet and rill erosion by the *Channel Erosion* value below that matches the watershed type. See the Watershed Erosion and Sediment Yield Summary (figure 3).

Channel Erosion	Watershed Characteristics
10% of S & R	Wide flood plains with meandering channels, numerous upland wetlands and depressions, diverse land uses scattered randomly throughout the watershed, numerous large ponds or other sediment traps, abrupt flattening of the main stream gradient in downstream direction. (Type A)
15% of S & R	Intermediate between Type A and Type B. (Type B)
20% of S & R	Narrow flood plains with straight channels, well drained convex uplands, uniformly distributed land uses, main channel uninterrupted by sudden gradient changes or man-made obstacles. (Type C)

Note: The above is a general rule of thumb, but judgment must also be used. If there is significant streambank or gully erosion greater than that listed above, for example in bluff-type watersheds along major rivers, values as much as 10-20 percent greater than what is listed can be used.

Example Channel Erosion Inventory

For a 10,000 acre watershed located in a Type B Watershed, the gross sheet and rill erosion is 57,900 tons.

The Channel Erosion factor is 15%.

57,900 tons x 0.15 = 8,685 tons (round to 8,700 tons channel erosion)

There is no evaluation needed for this source of erosion.

Total Gross Erosion

To arrive at a *Total Gross Erosion* figure for our example, simply go to Column 4 of the Watershed Erosion and Sediment Yield Summary (fig. 3) and add the values for Total Sheet and Rill, Total Ephemeral and Total Channel Erosion.

This procedure gives an estimated *current gross erosion* figure for the entire watershed. The effect of added conservation practices (cultural and structural) can be evaluated by substituting these new values into the summary and then simply comparing values. Also, subwatersheds can be broken out, using this same procedure with adjusted acreage.

Sediment Delivery Rate (SDR)

Only a portion of this Gross Erosion total actually is moved into a body of water (See fig. 4). One of the values used to help predict quantities delivered to the watershed outlet is the **Sediment Delivery Rate (SDR**). Off-site sediment results in the degradation of water quality through delivery of the sediments, nutrients, and chemicals to a water body. Sediment also reduces water storage volume which impacts upon water supply and recreational uses and diminishes the quality of fish habitat. Suspended sediments can also increase water treatment costs.

The **SDR** predicts the sediment that is available for transport at field edge. This is viewed as an on-site sediment delivery figure and varies for each type of erosion. It can also vary for each different landscape position and slope. For our generalized purposes, <u>only</u> <u>one</u> SDR will be applied to <u>each</u> erosion type. However, most watersheds have several SDR's for each type of erosion.

Sheet and Rill

Sheet (interrill) and rill erosion have SDR base values that range from literally "0" in depressional areas to 0.65 on slopes 10% and greater. An average on-site sediment delivery rate <u>(SDR) of 0.25 on slopes 5% and less and 0.55 on slopes 10% and greater</u> are good numbers to use. Select one of these numbers or use an average for a combination of slopes and put this value in Column 5 (fig. 3) for all sheet and rill erosion slopes and land uses. Multiply Column 5 by Column 4 and place this value in Column 6. Total this Column.

Ephemeral

Ephemeral erosion produces sediment that, in general, has a much more direct path into the stream system. In some cases, there will be an area prior to the entrance into the delivery system where some sediment deposition occurs (See fig. 4). As an average, use a <u>0.75 SDR</u>. Put this number in Column 5 and multiply by the *Ephemeral Gully Erosion* number in Column 4. Put the total in Column 6 under *Ephemeral Gully Erosion* (fig. 3).

Channel

Channel erosion delivers sediment directly into the stream system. Use a value of 0.85 to 1.0 for the SDR, depending on the predominance of gullies versus streams. Put this number in Column 5 and multiply by the value in Column 4 for Channel Erosion. Put total in Column 6 under *Channel Erosion Sources.*

The *Total Watershed Sediment* in Column 6 of the Watershed Erosion and Sediment Field Summary (fig. 3) now provides an estimate of the sediment that is available for transport or, in other words, ready to be moved through the stream system (Off-site).

Sediment Transport Factor (STF)

The other value needed to estimate sediment entering the lake is called the **Sediment Transport Factor (STF)**. This number predicts the efficiency and effectiveness of the entire stream system in moving sediment through it (fig. 4). Generally, use only one STF for each watershed. This number is based on stream density, slope, drainage coefficients, soils, roughness coefficients, etc. It also changes with the size of watershed. The larger the watershed, the less efficient it is in moving sediment, because there are so many more places for the sediment to be deposited.

For watersheds up to 20,000 acres in size, a chart has been provided (fig. 5) that allows a STF to be determined. A channel system with low transport efficiency entraps the sediments as they move through, thus less sediment is delivered to the lake or stream outlet. High transport efficiency channels have less sediment entrapments and thus produce higher sediment yields.

The following are some of the characteristics describing channel efficiency:

Efficiency	Watershed Characteristics	
Low	Wide flood plains with meandering channels, numerous upland wetlands and depressions, diverse land uses scattered randomly throughout the watershed, numerous large ponds or other sediment traps, abrupt flattening of the main stream gradient in downstream direction. (Type A)	***(See fig. 1A, 1B)***
Medium	Intermediate between Type A and Type C. (Type B)	
High	Narrow flood plains with straight channels, well drained convex uplands, uniformly distributed land uses, main channel uninterrupted by sudden gradient changes or man-made obstacles. (Type C)	***(See fig. 2A, 2B)***

For watersheds larger than 20,000 acres in size, a Sediment Transport Factor rating guide will need to be used. This chart is based on watershed characteristics, but is specific to each part of the state.

Summary

Knowing the total watershed area and estimating the Sediment Transport Factor (STF) from the table, a total estimate of sediment reaching the lake (or any such watershed outlet) can be determined. The STF is multiplied by the *Total Watershed Sediment* to obtain the total tons of sediment entering the lake on an average annual basis (fig. 3). This estimate is accurate for planning purposes and general discussion concerning conditions in the watershed. It is NOT accurate enough to use for engineering design purposes. For this, a more detailed inventory of channel erosion would be necessary on an individual sub-watershed basis. (See fig. 18 for example of data produced and summarized. See Example Sediment Report, pg. 49, for presentation of the summary data.)

Note: To convert tons to acre-feet, use the following formula:

$$\frac{\text{Tons Sediment}}{\text{Density}} \times 0.04591 = \text{Acre-Feet}$$

For *Density*, use a value of 95 pounds per cubic foot for sediment coming from predominately loess soils or silty alluvial soils and value of 110 pounds per cubic foot for glacial till soils or coarse-textured alluvium. These values are for "aerated" sediments or in other words, those that are NOT deposited INTO any kind of water body. Thus, they have an opportunity to dry out. Density values of 40 to 50 pounds per cubic foot are more appropriate for submerged sediments that are deposited directly into a body of water. What this says is that the same **tonage** of sediment will occupy much more **volume** if it enters a permanent pool of water.

R. D. Windhorn 2/01

Watershed Erosion and Sedimentation Summation Process

(Sheet and Rill Erosion Rate for Cropped* A / B slopes x Acres x SDR 1)

(Sheet and Rill Erosion Rate for Cropped* C / D slopes x Acres x SDR 2)

(Sheet and Rill Erosion Rate for Pasture* x Acres x SDR 3)

(Sheet and Rill Erosion Rate for Timber* x Acres x SDR 4)

(Sheet and Rill Erosion Rate for Urban* x Acres x SDR 5)

(Ephemeral Rate x Acres of affected cropland x SDR 6)

(Gully Erosion Rate x Feet of eroding gullies x SDR 7)

(Streambank Erosion Rate x Feet of eroding streambank x SDR 8)

sum equals

Subtotal of Sediment Available for Transport

times

Sediment Transport Factor (STF)

product equals

Total Suspended Sediment Delivered to Watershed Outlet

** Can be further subdivided*

Reminders

Other Issues to Consider

- Consistency! Consistency! Consistency!
- *Rates* of erosion are needed to complete the summary.
- Use guidelines. Do not overestimate channel erosion in the entire watershed
- Sheet and rill data can be gathered using different methods. Don't get bogged down!
- Use common sense to deal with field problems that arise.
- Use your normal inventory process. Don't adjust your methods to fit this procedure.
- Obtain acreage figures for each land use break in the watershed.
- **Local people must be comfortable with data gathering and results.**

-Photo 1-

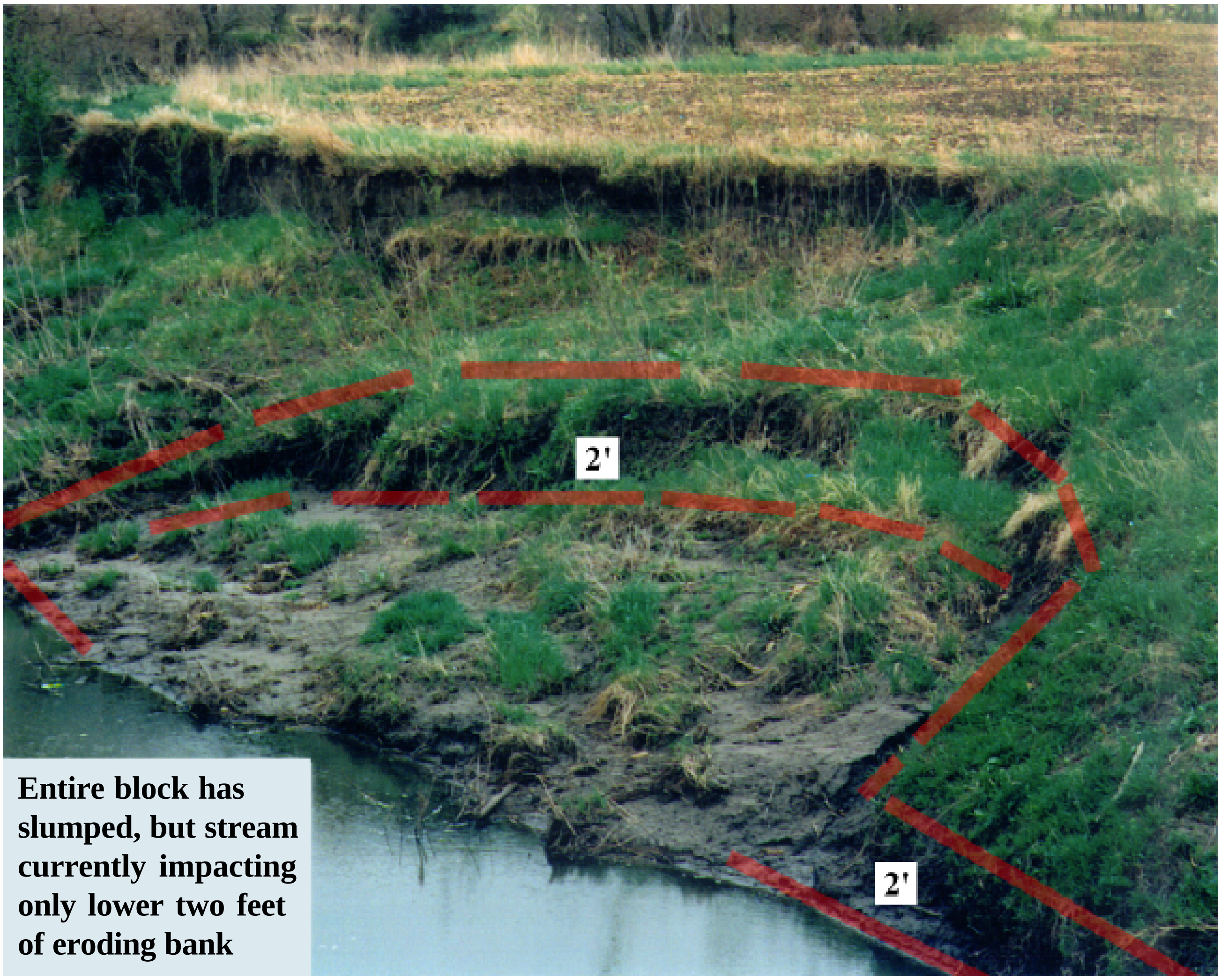
Average Annual Rate of Recession

Slight **Rate 0.03' or less**

-Photo 2-

Average Annual Rate of Recession

Moderate **Rate 0.2’**



-Photo 3-

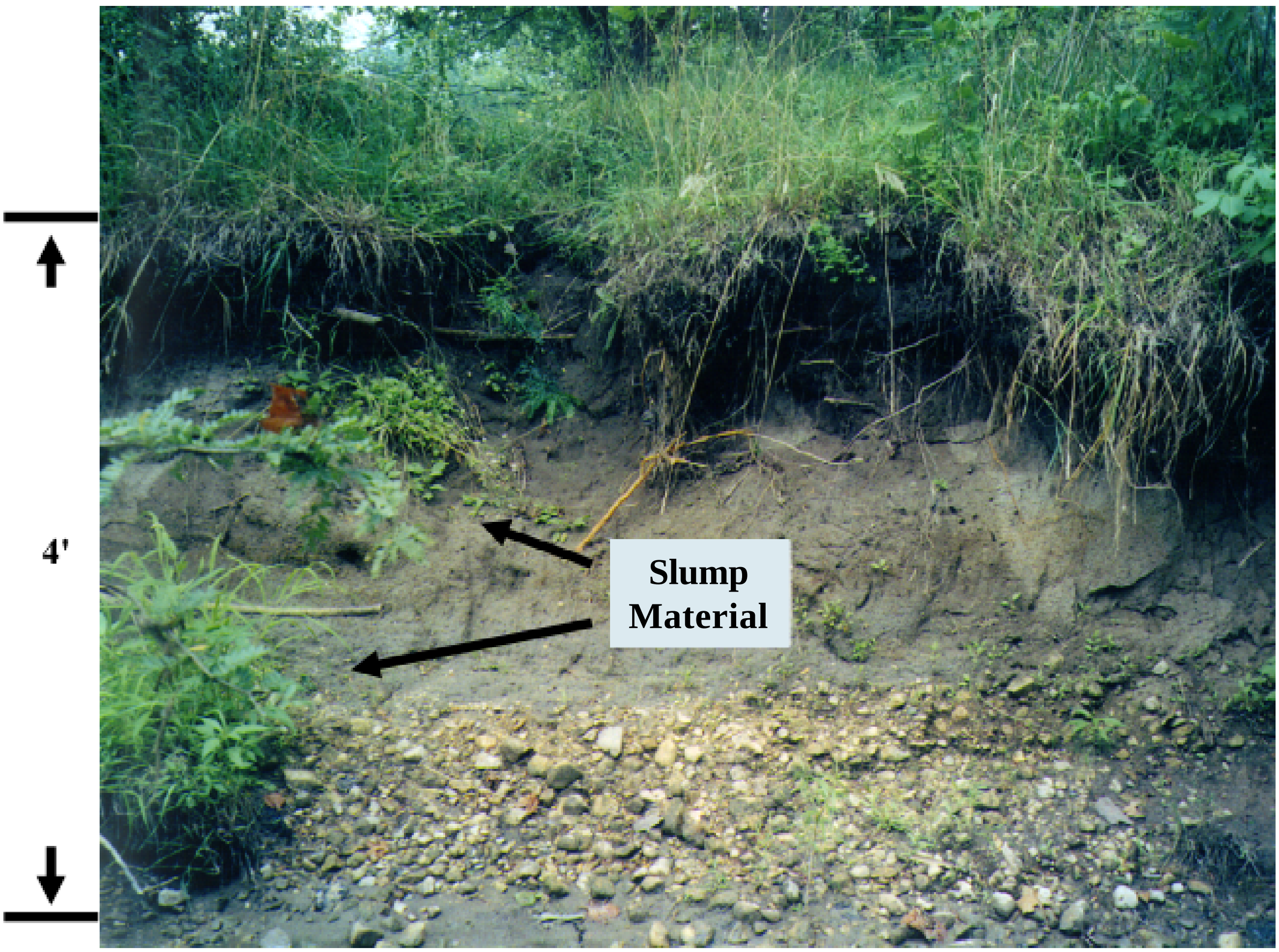
Average Annual Rate of Recession

Moderate **Rate 0.15’**

-Photo 4-

Average Annual Rate of Recession

Severe **Rate 0.40’**



-Photo 5-

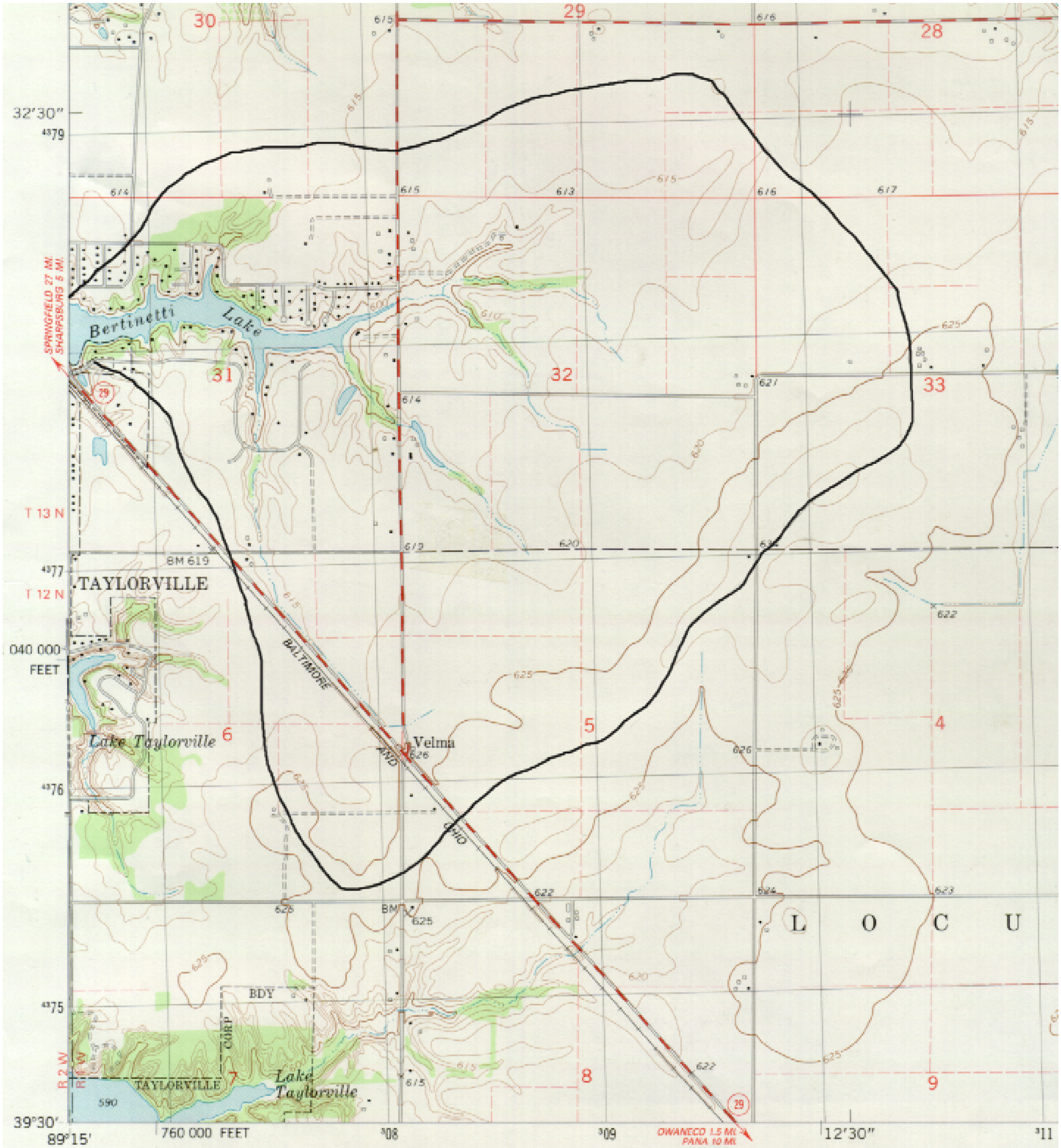
Average Annual Rate of Recession

Very Severe **Rate 0.5’**

-Figure 1A-

Low Channel Transport Efficiency

Type A

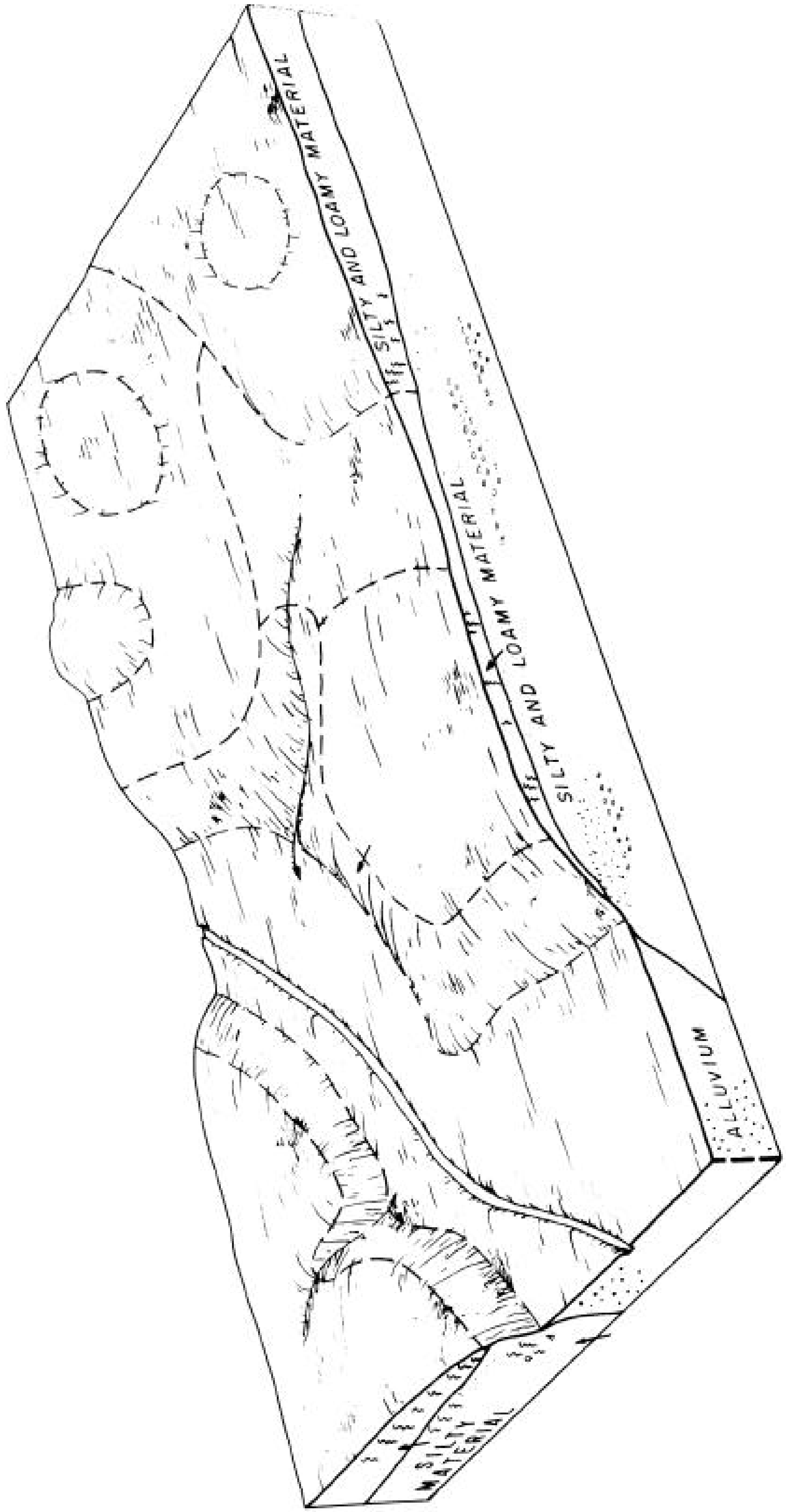


Widely-spaced lines indicate low slopes.

-Figure 1B-

Low Channel Transport Efficiency

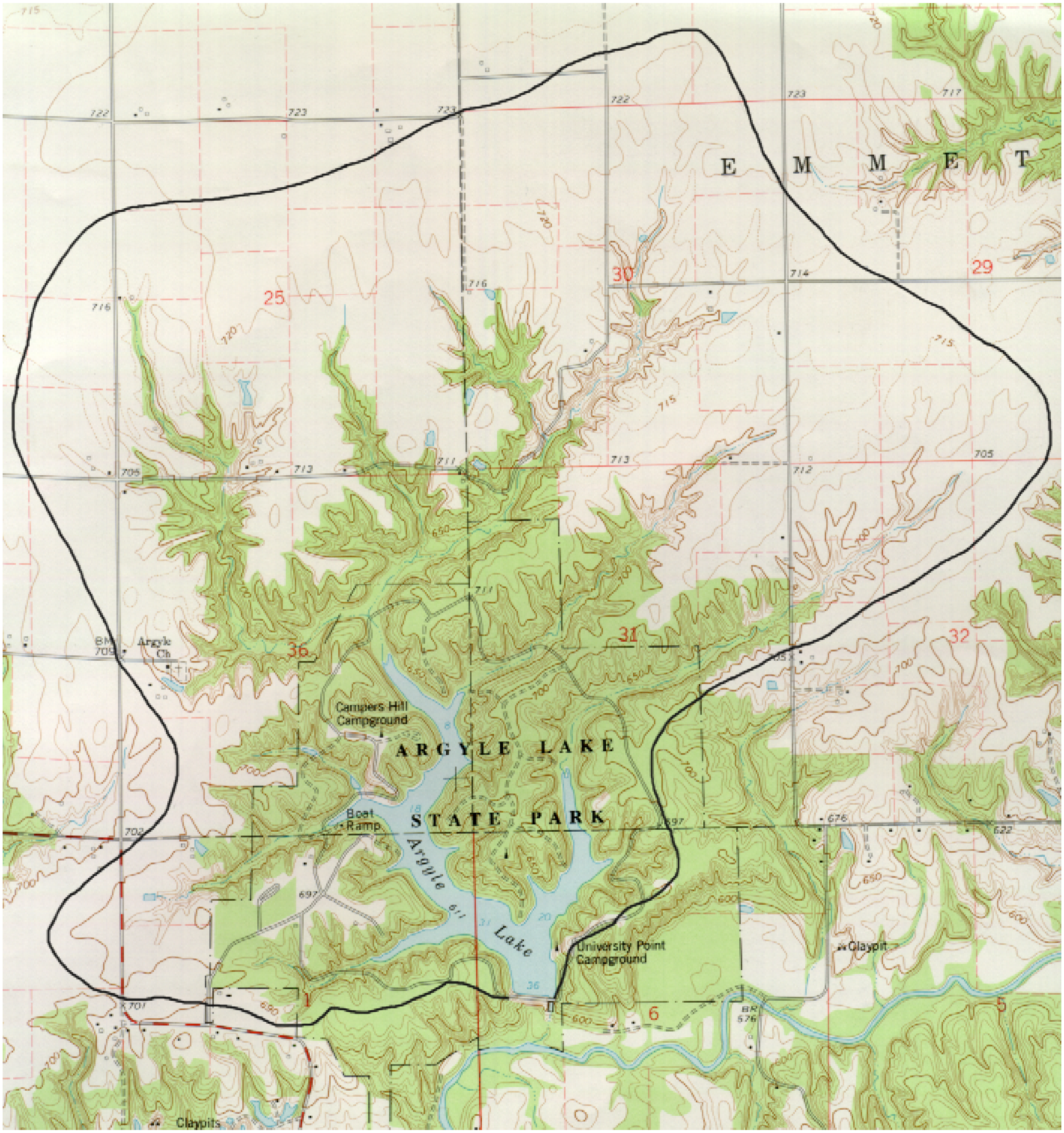
Type A



-Figure 2A-

High Channel Transport Efficiency

Type C

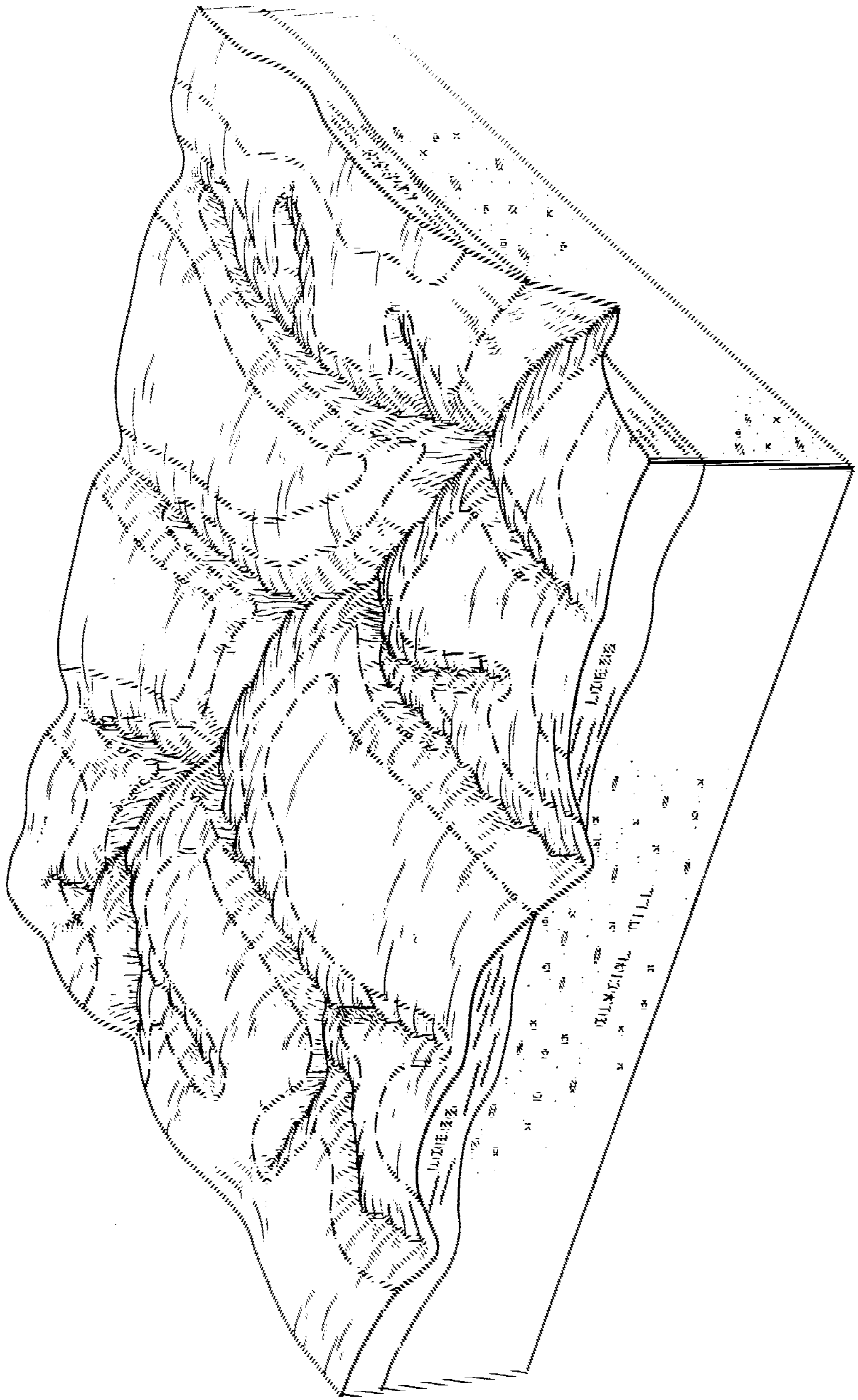


Steep slopes are indicated by closely-spaced lines.

-Figure 2B-

High Channel Transport Efficiency

Type C



-Figure 3-

Watershed Erosion and Sediment Yield Summary

			Present Conditions			
			Erosion		Sediment Yield	
Sheet and Rill Erosion:	Slope Group	Area Ac.	Average Rate T/A/Yr	Gross T	SDR	Yield T
Cropland	"A"	2,400	2	4,800	0.6	2,900
	"A"	300	6	1,800	0.6	1,100
	"B"	500	4	2,000	0.6	1,200
	"B"	2,500	8	20,000	0.6	12,000
	"C"	300	4	1,200	0.6	700
	"C"	800	13	10,400	0.6	6,200
	"D"	100	4	400	0.6	250
	"D"	400	25	10,000	0.6	6,000
Grassland	All	400	2	800	0.6	500
	All	100	12	1,200	0.6	700
Woodland	All	800	1	800	0.6	500
	All	200	20	4,000	0.6	2,500
Urban Land	All	500	1	500	0.6	300
Water Area	-	500	-	-	-	-
Total Sheet and Rill Erosion				57,900	XXX	35,000
Total Ephemeral Gully Erosion				7,200	0.85	6,120
Total Channel Erosion				8,700	1.0	8,700
Total Watershed		**10,000**		**73,800**		**49,820**
Sediment Yield Off-Site (STF = 0.38)					*0.38 x 49,820 =*	**18,900**

-Figure 4- R. D. Windhorn 11/13/00

Sediment Delivery and Transport

Sheet and Rill Erosion

Deposition <<<< >>>> Movement on-site & off site

Depression, field edges, farm ponds, conservation structures
(silt and clay)

SDR #1

Concentrated flow Sheet flow

Sheet flow on adjacent slopes can enter the body of water directly

Ephemeral Erosion

Deposition <<<< >>>> Movement on-site & off site

Depression, field edges, heads of gullies, slope breaks, farm ponds, conservation structures
(silt, clay, vf & f sand)

SDR #2

Gully Erosion

Deposition <<<< >>>> Movement on-site & off site

Road culvert cutoffs, highway cutoffs, ponds, road ditches, gully channel itself, gully flood plain
(silt, sand & gravel)

SDR #3

Streambank Erosion

Deposition <<<< >>>> Movement on-site & off site

Flood plain, within channel itself, channel sides, wetlands
(sand, gravel & cobbles)

SDR #4

Stream System

Sediment Transport Factor (STF)

Lake/Structure/River

-Figure 5-

Channel Transport Factor
STF

Watershed Area (Acres)	Watershed Efficiency Low	Medium	High
0 - 1,999	0.43	0.64	0.86
2,000 - 3,999	0.34	0.51	0.67
4,000 - 5,999	0.30	0.45	0.60
6,000 - 7,999	0.28	0.42	0.55
8,000 - 9,999	0.27	0.40	0.52
10,000 - 11,999	0.26	0.38	0.49
12,000 - 13,999	0.25	0.37	0.47
14,000 - 15,999	0.24	0.36	0.45
16,000 - 17,999	0.23	0.35	0.44
18,000 - 20,000	0.22	0.34	0.43

R. D. Windhorn 7/00

-Figure 6A-

Channel Inventory Form

Watershed______________________________ Name___________________________ Date_______

Start Transect at____ Transect No._________

Type of Channel Erosion____________________________

L (x) H (x) Lat. Rec. Rate (x) Density / 2000 = Tons / Year

	Reach Num	Length (ft)	Height (ft)	Lateral Recession Rate (ft/yr)	Density (pcf)	Erosion (tons/yr)	Comments
R	1						
L	2						
R	3						
L	4						
R	5						
L	6						
R	7						
L	8						
R	9						
L	10						
R	11						
L	12						
R	13						
L	14						
R	15						
L	16						

Total = _________ XXXXX XXXXXXX XXXX ________

EXAMPLE

-Figure 6B-

R. D. Windhorn 7/00

Channel Inventory Form

Watershed Anywhere Watershed Name R. D. Windhorn Date 12/25/00

Start Transect at E-W Road, Go North 1300' Transect No. 1-A

Type of Channel Erosion Streambank

L (x) H (x) Lat. Rec. Rate (x) Density / 2000 = Tons / Year

	Reach Num	Length (ft)	Height (ft)	Lateral Recession Rate (ft/yr)	Density (pcf)	Erosion (tons/yr)	Comments
R	1	100	2	0.13	95	1.2	
L	2	100	1	0.03	95	0.1	
R	3	200	0.5	0.03	95	0.1	
L	4	200	3	0.4	95	11.4	
R	5	50	6	0.4	95	5.7	
L	6	50	1	0.13	95	0.3	
R	7	300	0.5	0.03	95	0.2	
L	8	300	1.5	0.13	95	2.8	
R	9	150	2	0.3	95	4.3	
L	10	150	1	0.03	95	0.2	
R	11	300	0.5	0.03	110	0.2	
L	12	300	1.5	0.3	110	7.4	
R	13	200	1	0.13	110	1.4	
L	14	200	4	0.6	110	26.4	
R	15	2600/2 = 1300					
L	16						

Total = 1300 XXXXX XXXXXXX XXXX 61.7T (95 #/foot of streambank)

-Figure 7-

R. D. Windhorn 6/99

Lateral Recession Rates

Gully Erosion

Lateral Recession Rate (ft/yr)	Ave. (ft/yr)	Category	Description
0.01 - 0.05	0.03	Slight	Some bare bank but active erosion not readily apparent. Some rills, but no vegetative overhang. No exposed tree roots.
0.06 - 0.2	0.13	Moderate	Bank is predominantly bare with some rills and vegetative overhang. Some exposed tree roots. No slumps. Gullies generally V-shaped.
0.3 - 0.5	0.40	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees. Slumping or rotational slips are present. Some changes in cultural features, such as fencelines out of alignment or pipelines exposed. Gullies becoming more U-shaped as the lower part of the channel erodes. Knickpoints present in channel bottom.
0.5 - 2.0	1.5	Very Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and fallen trees. Slumping of sidewalls quite evident. Gullies are U-shaped, with vertical sidewalls at base of channels. Knickpoints present in channel bottom, with overfalls of 2 feet and greater possible. Soil material has often accumulated at base of slopes.

What recession rates mean:

at 0.01 feet / year and 90 pcf equals 20 tons / acre / year

at 0.05 feet / year and 90 pcf equals 100 tons / acre/ year

visible rills on the bank equals 12 tons / acre / year

***NOTE**: at 90 pcf, 1 acre-foot equals 2000 tons*

-Figure 8-

R. D. Windhorn 6/99

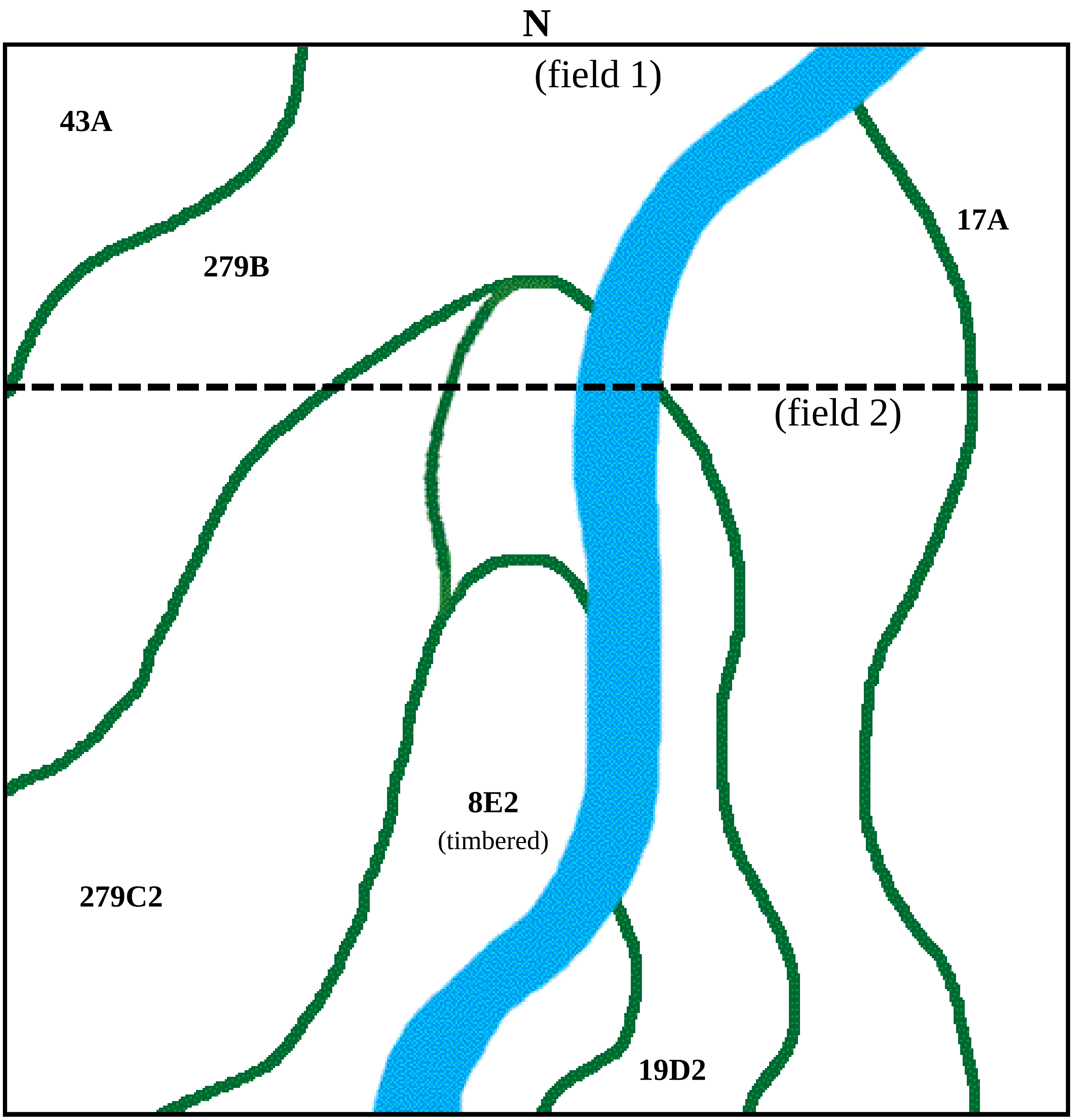
Lateral Recession Rates

Streambank Erosion

Lateral Recession Rate (ft/yr)	Ave. (ft/yr)	Category	Description
0.01 - 0.05	0.03	Slight	Some bare bank but active erosion not readily apparent. No vegetative overhang. No exposed tree roots. Bank height minimal.
0.06 - 0.2	0.13	Moderate	Bank is predominantly bare with some vegetative overhang. Some exposed tree roots. No slumping evident.
0.3 - 0.5	0.40	Severe	Bank is bare with very noticeable vegetative overhang. Many tree roots exposed and some fallen trees. Slumping or rotational slips are present. Some changes in cultural features, such as missing fence posts and realignment of roads.
0.5 - 2.0	1.5	Very Severe	Bank is bare and vertical or nearly vertical. Soil material has accumulated at base of slope or in water. Many fallen trees and/or extensive vegetative overhang. Cultural features exposed or removed or extensively alterered. Numerous slumps or rotational slips present. Generally silty or sandy bank material, NOT glacial till or exposed shale bedrock.
2.0 - 5.0	3.5	Extremely Severe	Bank is bare and vertical. Soil material has accumulated at base of slope and oftentimes still contains living grass or other vegetative material. Extensive cracking of the earth parallel to the exposed face above the bank. Generally evidence of "block-size" material that has either recently fallen in or is about to fall in. Can be "pillars" of soil materials that have already been loosened by stream and indicate imminent failure into the stream. Trees have been undercut and lie in stream, often with root balls intact. Silty or sandy bank material, NOT glacial till or exposed shale bedrock. (These rates should be verified with several observations or with actual streambank monitoring.)

-Figure 9-

Determination of Sheet & Rill Erosion Rates



Average the rates of erosion for A & B slopes:	17A 43A 279B
Average the rates of erosion for C & greater slopes:	279C2 19D2

-Figure 10-

Resource Inventory

Watershed ______________________
County ______________________
Date ______________________

USLE R ______________________
RUSLE R ______________________
Assisted By ______________________

Sheet & Rill Erosion

Tract No.	Field No.	Land Use	Soil Map Unit	Acres	Crop Rotation	Slope Length	Slope %	LS	K	C	P	Av Soil Loss (t/ac/yr)	No-Till (acres)	Mulch Till (acres)	Grassed Waterway (feet)	Terrace (feet)	WASCOB (no.)	Grade Stab. Structure (no.)	Pond (no.)	Filter Strips (acres)	Other (units)

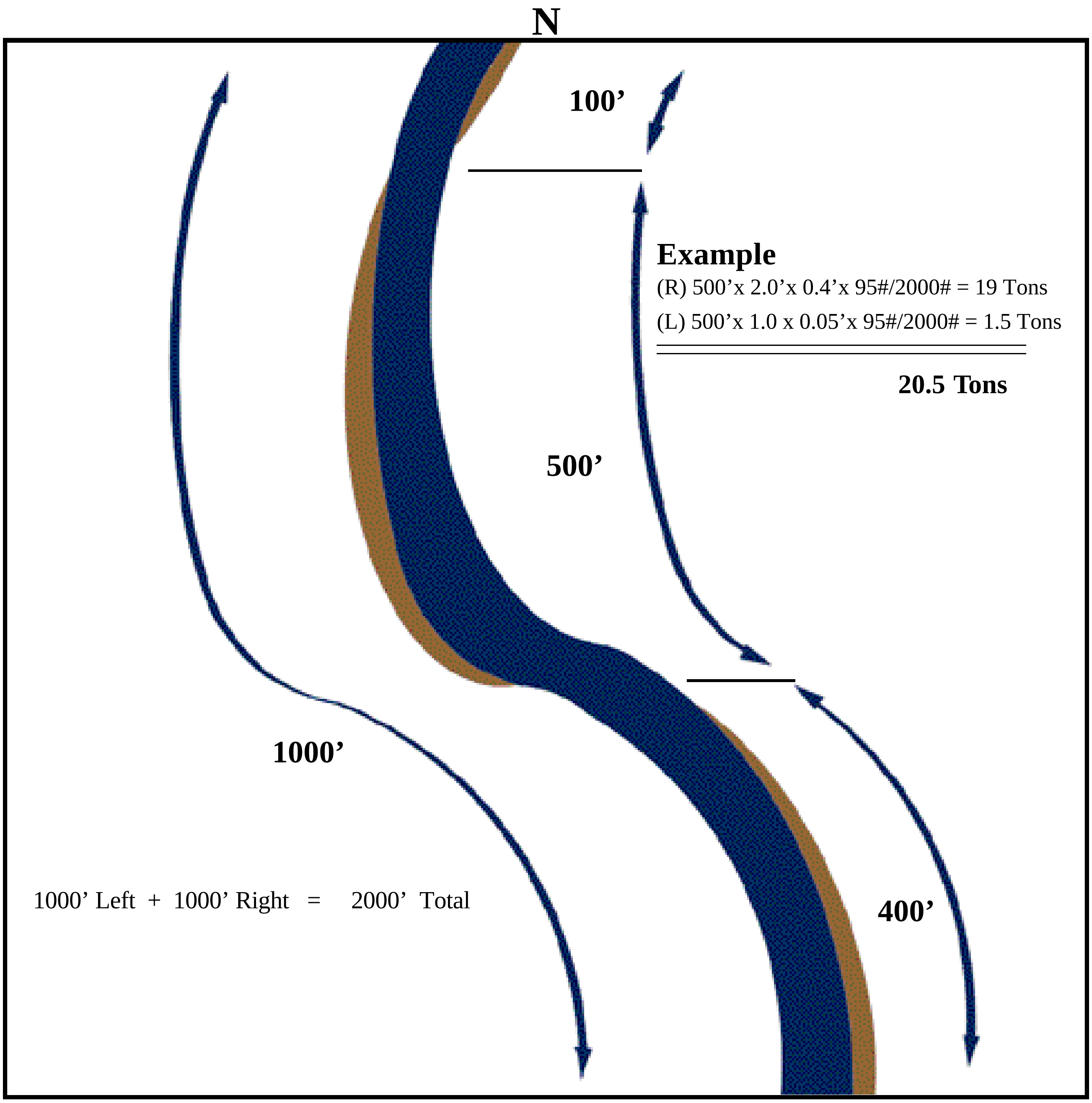
Ephemeral Erosion

Tract No.	Field No.	Tillage Constant 0.069 (1)	Length Factor Table 1 (2)	Slope Factor Table 2 (3)	Tillage Factor Table 3 (4)	Length (feet)	Erosion (tons)

Conservation Management Notes

-Figure 11-

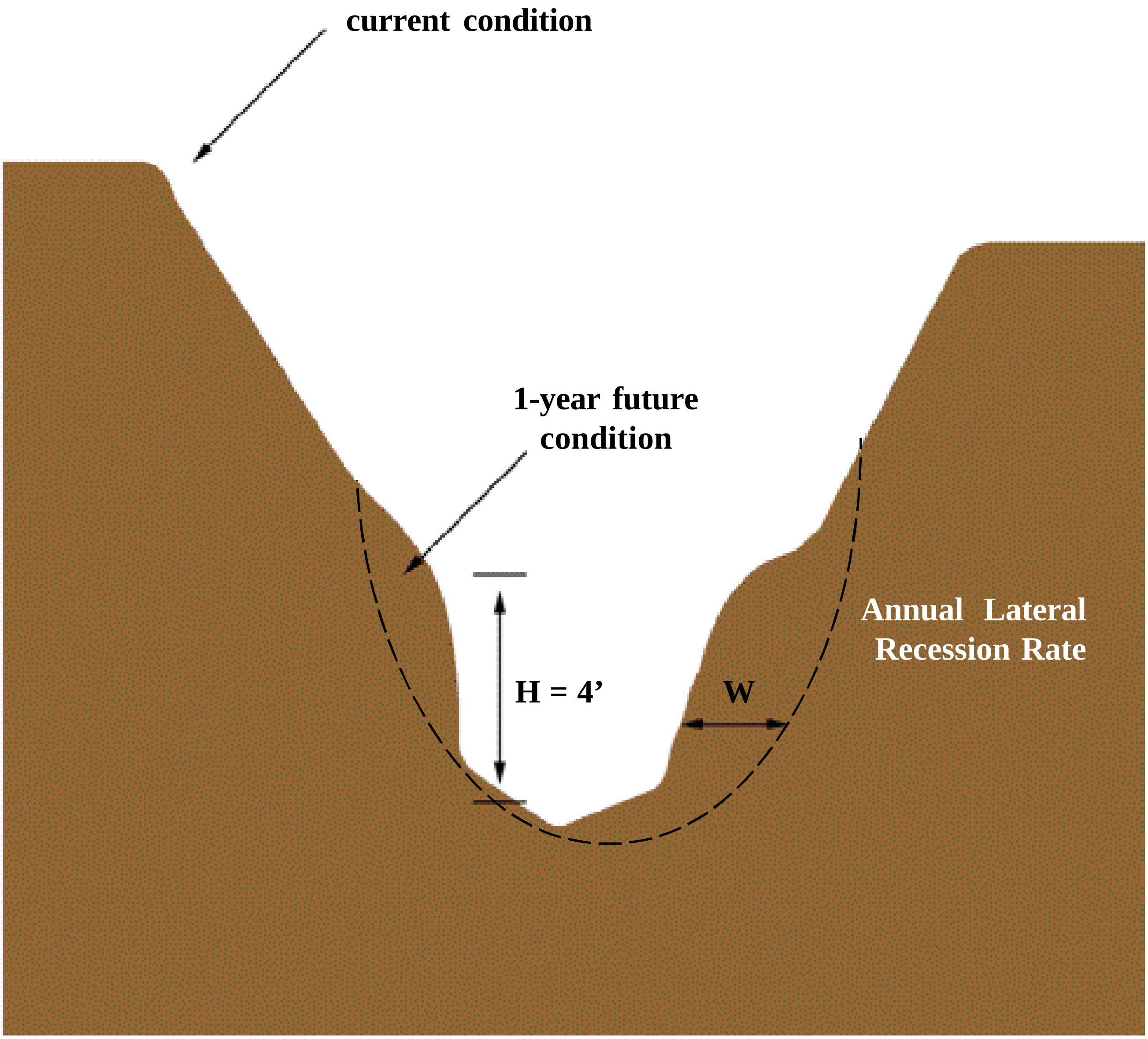
Channel Inventory Procedure



- Walk the thalweg or middle section. Measure the meandering reaches of the stream banks.
- The breaks are determined by the most severely eroding side.
- Use the total (2000’ ***not*** 1000’) to place on the worksheet.

-Figure 12-

Volume Determination Using Lateral Recession Rate

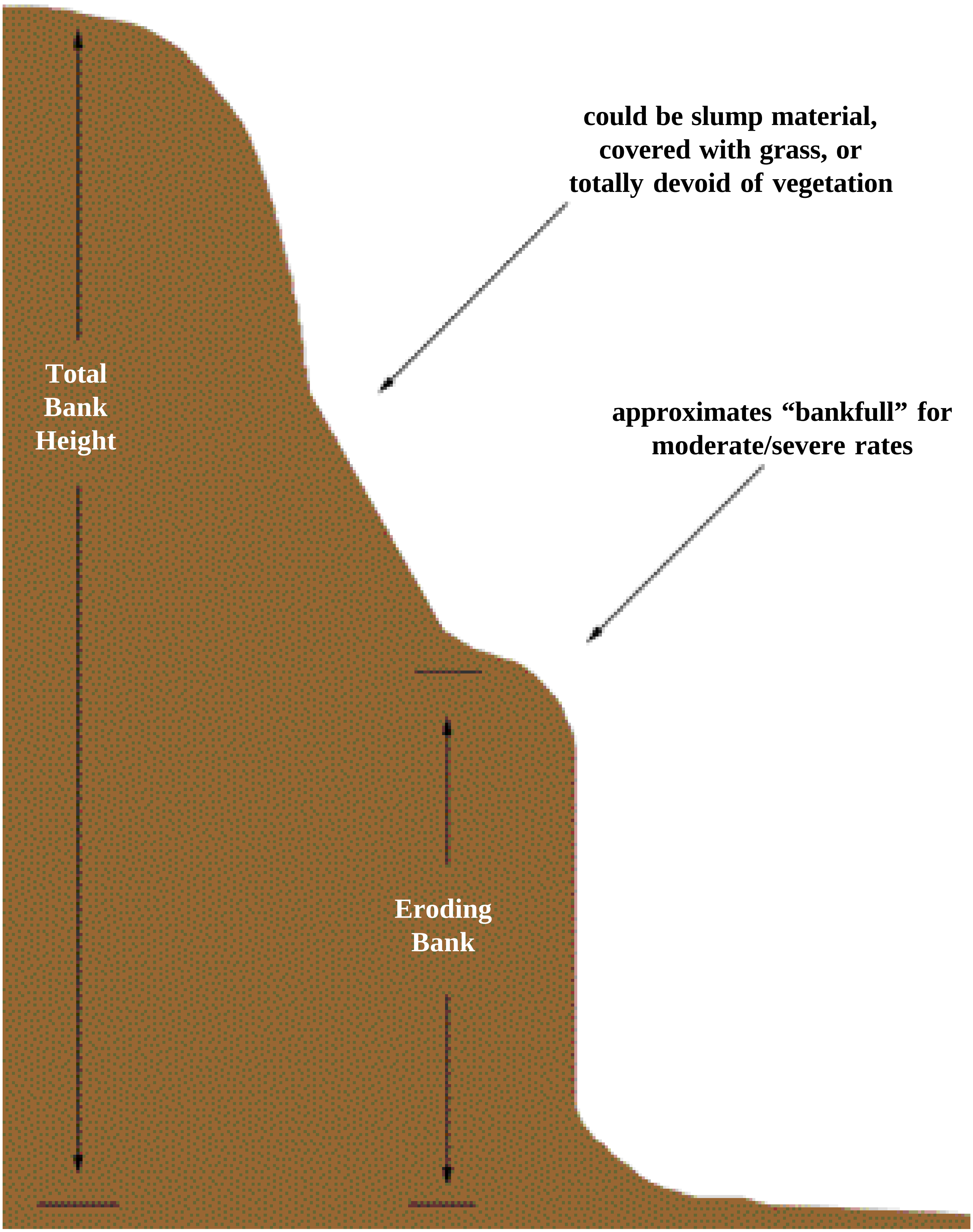


$$L \times H \times W = \text{Volume}$$

Length *(Gully Segment Eroding)* **x** **Heigh**t *(Eroding Area)* **x** **Width** *(Lost Each Year - Lateral Recession Rate)* **=** **Volume** *(Annual Gully & Streambank Erosion)*

-Figure 13-

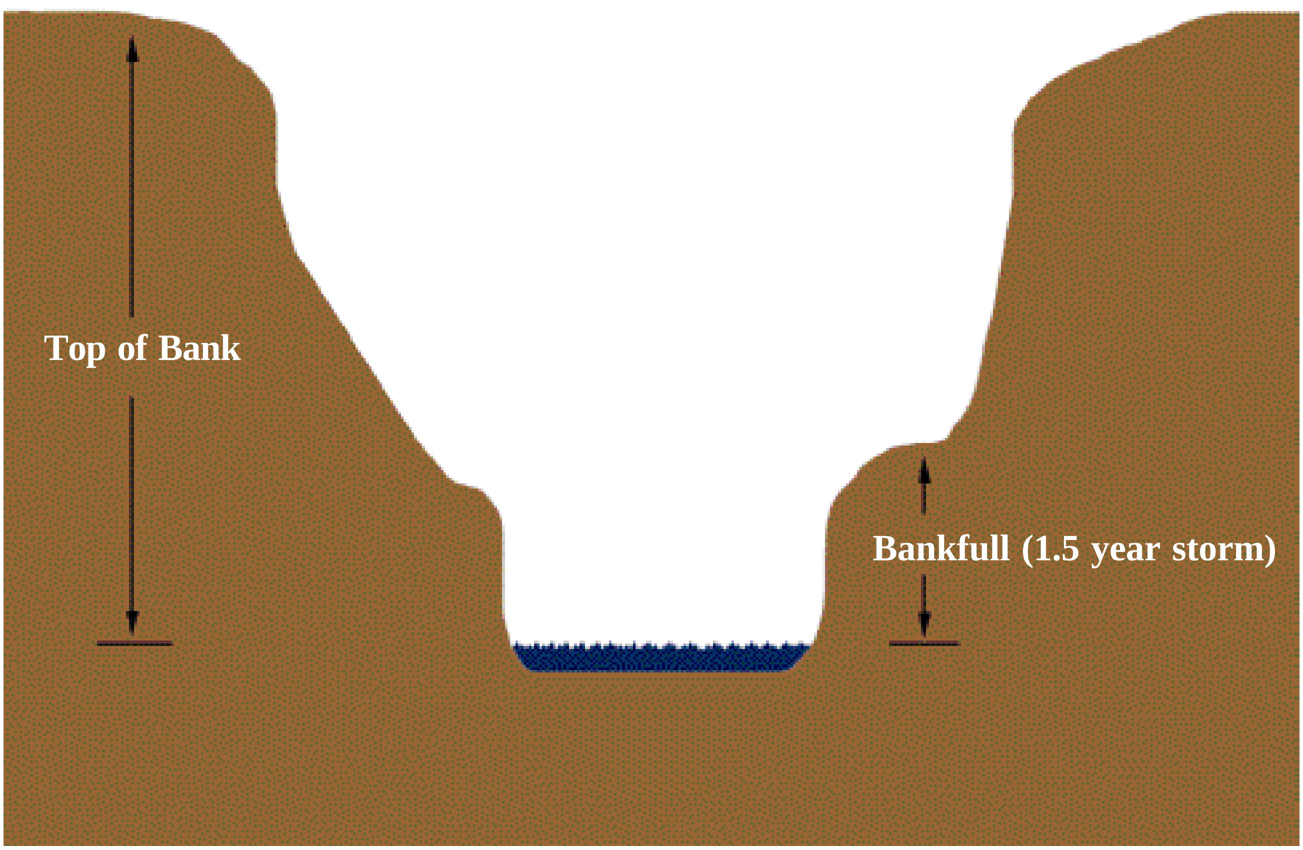
Eroding Bank Height



Use Photo 3 for reference.

-Figure 14-

Eroding Bank Height

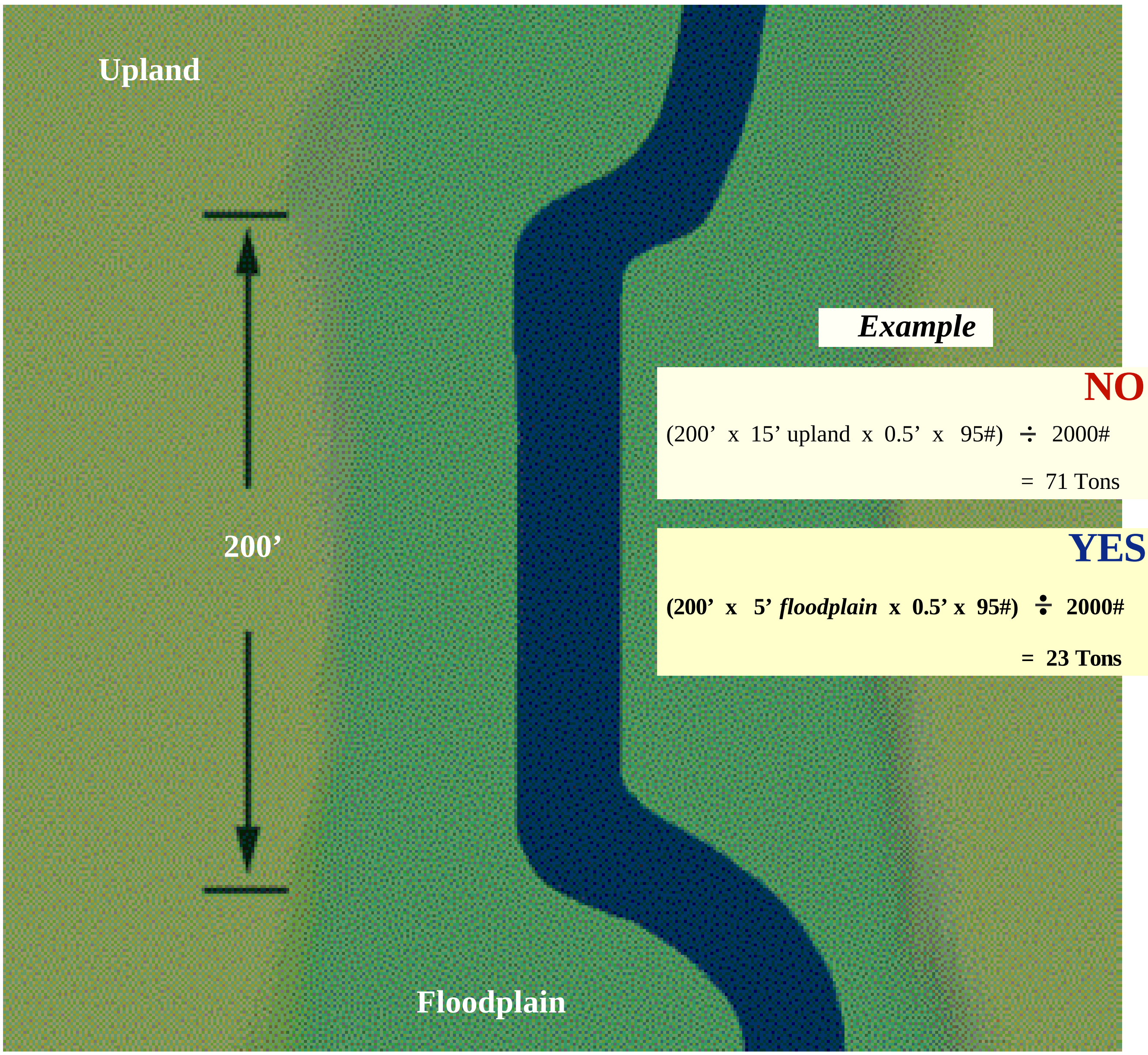


Bankfull ≠ Top of Bank

-Figure 15-

Eroding Bank Height

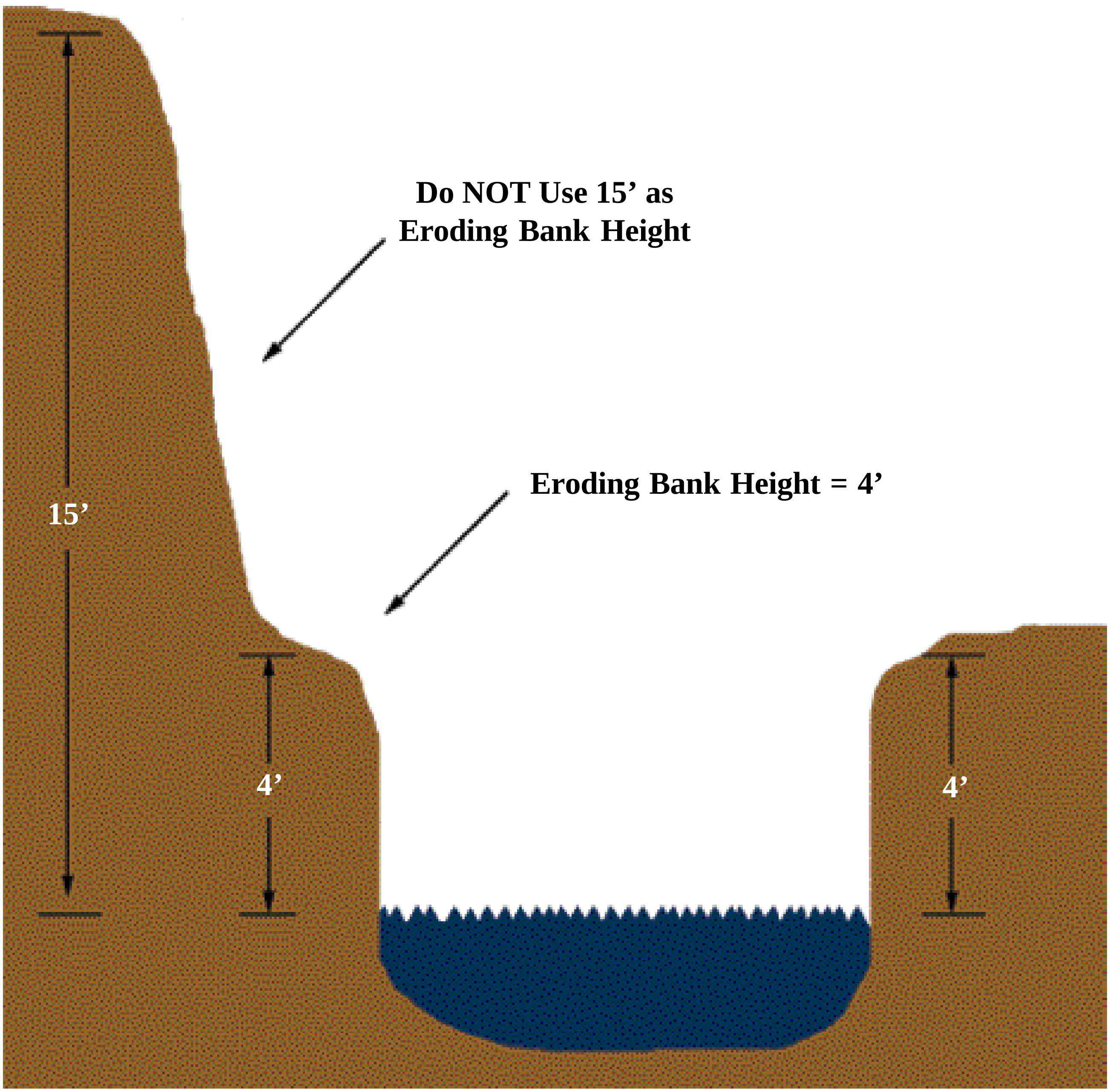
shown from above



Use Photo 3 for reference.

-Figure 16-

Eroding Bank Height



4’ is the maximum, by definition, of ***bankfull***.

-Figure 17-

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Channel Erosion Quantities

Section Eroding = 100 feet long

Bank	Recession rate	Tons
4 foot high eroding bank	@ 0.15 foot recession rate	2.8
	@ 0.5	9.5
	@ 1.0	19.0
	@ 2.0	38.0
6 foot high eroding bank	@ 0.15 foot recession rate	4.3
	@ 0.5	14.0
	@ 1.0	28.5
	@ 2.0	57.0
8 foot high eroding bank	@ 0.15 foot recession rate	5.7
	@ 0.5	19.0
	@ 1.0	38.0
	@ 2.0	76.0
10 foot high eroding bank	@ 0.15 foot recession rate	7.1
	@ 0.5	24.0
	@ 1.0	47.5
	@ 2.0	95.0

Section Eroding = 200 feet long

Bank	Recession rate	Tons
4 foot high eroding bank	@ 0.15 foot recession rate	5.7
	@ 0.5	19.0
	@ 1.0	38.0
	@ 2.0	76.0
6 foot high eroding bank	@ 0.15 foot recession rate	8.6
	@ 0.5	28.5
	@ 1.0	57.0
	@ 2.0	114.0
8 foot high eroding bank	@ 0.15 foot recession rate	11.4
	@ 0.5	38.0
	@ 1.0	76.0
	@ 2.0	152.0
10 foot high eroding bank	@ 0.15 foot recession rate	14.3
	@ 0.5	47.5
	@ 1.0	95.0
	@ 2.0	190.0

Note: Use 95 pounds per cubic foot

Section Eroding = 300 feet long			**Tons**
4 foot high eroding bank	@ 0.15	foot recession rate	8.6
	@ 0.5		28.5
	@ 1.0		57.0
	@ 2.0		114.0
6 foot high eroding bank	@ 0.15	foot recession rate	12.8
	@ 0.5		43.0
	@ 1.0		85.5
	@ 2.0		171.0
8 foot high eroding bank	@ 0.15	foot recession rate	17.1
	@ 0.5		57.0
	@ 1.0		114.0
	@ 2.0		228.0
10 foot high eroding bank	@ 0.15	foot recession rate	21.4
	@ 0.5		71.0
	@ 1.0		142.0
	@ 2.0		285.0

Section Eroding = 400 feet long			
4 foot high eroding bank	@ 0.15	foot recession rate	11.4
	@ 0.5		38.0
	@ 1.0		76.0
	@ 2.0		152.0
6 foot high eroding bank	@ 0.15	foot recession rate	17.1
	@ 0.5		57.0
	@ 1.0		114.0
	@ 2.0		228.0
8 foot high eroding bank	@ 0.15	foot recession rate	22.8
	@ 0.5		76.0
	@ 1.0		152.0
	@ 2.0		304.0
10 foot high eroding bank	@ 0.15	foot recession rate	28.5
	@ 0.5		95.0
	@ 1.0		190.0
	@ 2.0		380.0

Note: Use 95 pounds per cubic foot

WATERSHED SUMMARY (Oct. 1998)	Argyle Lake	Lake Bloomington	Canteen Creek	Little Canteen Creek	Carbon Cliff	Lake Carlinville	Carr Creek	Crotty Creek	Lake Decatur	Governor Bond	Mauvais Terre	Nippersink	Palmer Creek	Powdermill Creek
(Updated after Metro-East Re-Eval.)							(incl. Wilson)							
												(Wonder Lake)		
Acres	3,618	43,100	14,500	5,095	1,470	15,966	6,818	737	593,400	22,081	20,510	62,270	2,932	2,765
Square miles	5.65	67.34	22.66	7.96	2.3	24.95	10.6	1.15	927.2	34.5	32	97.3	4.6	4.32
EROSION (tons)														
							(RUSLE)			0			(RUSLE)	
Sheet and Rill	11,362	128,200	109,486	28,070		77,500	101,000	1,129	2,460,600	98,546	121,000	304,100	43,000	10,150
Ephemeral	11,000	64,870	26,930	3,920		3,100	30,300	170		11,825	12,730	44,400	13,900	1,330
Gully	10,235	3,820	0.0496 20,250	15,000	(@0.017) 420	9,800	10,400	(@0.065) 2,866	185,240	(@0.022) 11,390	6,270	(@0.02) 7,560	7,375	(@0.04) 5,570
Streambank	(included)	(included)	2,800	0.055 725	(@ 0.032) 290	1,800	1,100	(@0.045) 235		(@0.025) 1,050	(included)	(@0.01) 575	900	(@0.055) 2,000
Shoreline	0	1,000	0	0	0	1,100								0
GROSS EROSION	32,597	197,890	159,466	47,714		93,400	142,800	4,400	2,645,840	122,800	140,000	356,635	64,700	19,050
Erosion (tons) / Acre watershed	9	4.6	11	9.4		5.85	20.9	5.97	4.46	5.56	6.8	5.7	22.1	6.9
Erosion (tons) / Square mile watershed	5,769.40	2,939	7,037	5,994		3,743	13,470	3,826	2,854	3,559	4375	3,665	14,000	4,398
SDR														
Sheet and Rill	0.2	0.245	.65 and .75	.65 and .75		0.13	.65 and .75	0.25		0.71	0.13	(ave.) 0.58	0.65 and 0.75	0.65 and 0.75
Ephemeral	0.25	0.245	0.75	0.8		0.35	0.85	0.5		0.9	0.2	0.75	0.8	0.85
Gully	0.75	0.95	0.9	0.9	0.9	0.53	0.95	0.8	0.16	0.9	0.63	0.85	0.95	0.95
Streambank	0.75		1	1	1	0.53	1	1		1	(included)	1	1	1
Shoreline	0	1	0	0	0	0		0		0	0	0		0
(or Watershed SDR)	-0.37	0.26							0.15					
Sediment from each source (tons)														
Sheet and Rill	1,806	31,430	77,734	20,160		9,900	73,800	283		70,000	15,864	201,500	28,500	7,459
Ephemeral	2,750	15,890	20,000	3,100		1,100	25,300	84		10,600	2,496	33,300	11,100	1,130
Gully	7,676	3,630	18,000	13,500	375	6,700	9,800	2,293		10,250	3,940	6,425	7,000	5,291
Streambank			2,800	725	290	(included)	1,100	235		1,050	(included)	575	900	2,000
Shoreline	0	1,000	0	0	0	(included)		below Rt 6 135		0				0
TOTAL SEDIMENT	12,232	51,960	(Rt. 157) 118,534	(Rt. 157) 37,484		17,765	110,000	3,030	385,310	91,900	22,300	241,800	47,500	15,880
Sediment Transport Factor (if used)	no	no	0.41	0.59	0.78	no	0.55	no	no	0.35	no	0.15	0.68	0.66
(In-watershed Sediment Basins?)			0.15	No			0.05						0.1	No
DELIVERED SEDIMENT (tons)	12,232	51,960	41,000	22,100		17,765	57,000	I & M 3,030	385,310	32,200	22,300	36,270	29,000	(Rt. 157) 10,400
Sediment (tons) / Acre of watershed	3.4	1.21	2.8	4.3		1.11	8.4	4.11	0.65	1.46	1.09	0.58	9.9	3.8
Sediment (tons) / Square mile of watershed	2,165	772	1,809	2,776		712	5,380	2,635	416	933	697	373	6,300	2,407
Sediment (ac-ft) aerated at 95 pcf			19.8	10.7			27.5						14	5
Sediment (ac-ft) submerged at 45 pcf			41.8	22.8			58.2						29.6	10.6
Sediment (cu-yds) aerated at 95 pcf			31,900	17,200										8,000
Sediment (cu-yds) submerged at 45 pcf			67,000	36,300										17,000
Trap Efficiency	0.96	0.93				0.87		0.98	0.65	0.9	0.65	0.8		0
Deposited in Sink (tons)	8,247**	48,400				15,300		both sinks 2,970	250,450	28,980	14,500	29,000		(@ Rt 158) 8,100
Pounds / cubic foot (submerged)	42	50	45			54				50	53	50		95
Pounds / cubic foot (aerated)			95											
Deposited in Sink (acre-feet)	9	44.4				13		I & M only 1.1		26.6	12.5	26.6		3.9
(cubic yards)														6,290
Through Sink, back into system (tons)	344	3,640				2,465		60	134,860	3,310	7,800	7,270		
	** 3640 trapped in road culverts													

Richland Creek	Sand Creek	Schoenberger Creek	Schoolhouse	Spring Lake	Lake Taylorville	Washington Lake	Judy's	Embarras River	Burdick's	Mackinaw River
17,223	8,370	7,704	4,615	12,966	80,400	6,822	5,527	1,566,450	1,789	744,300
26.91	13.08	12.04	7.21	20.26	125.63	10.66	8.64	2,440	2.81	1,163
66,000	14,600	19,922	35,639	49,775	250,900	16,130	47,115	5,172,800	14,839	3,000,000
9,900	1,460	2,526	7,100	5,000	37,600	3,200	9,600	775,920	3,030	280,000
(@0.0496) 46,000	ave. .035 2,100	(@0.04) 13,250	11,600	(ave. 0.21) 10,400	17,500	1,030	10,500	683,760	3,700	250,000
(@0.055) 10,000	(@0.07) 1,700	(@0.055) 4,000	1,200	(@0.014) 405	12,500	140	670	93,500	700	200,000
0	0	0		350	0	710				
132,000	19,800	39,698	55,539	65,930	318,500	21,210	67,885	6,725,980	22,269	3,730,000
7.66	2.37	5.2	12	5.08	3.96	3.11	12.3	4.29	12.4	5.01
4,905	1,514	3,297	7,703	3,254	2,535	1,990	7,857	2,756	7,925	3,207
0.75	0.25	0.65 and 0.75	0.65 and 0.75	0.75	0.27	0.75	0.65 and 0.75	0.75	0.65 and 0.75	0.7
0.85	0.35	0.8	0.85	0.75	0.4	0.85	0.85	0.85	0.85	0.8
0.9	0.75	0.9	0.95	0.85	0.95	0.85	0.95	0.8	0.95	0.85
1	0.9	1	1	1	1	1	1	1	1	1
0	0			1	0	1				
49,500	3,600	14,200	26,016	37,331	67,700	12,097	34,000	3,879,600	10,981	2,100,000
8,400	500	2,000	6,035	3,750	15,000	2,700	8,160	659,500	2,576	224,000
41,000	1,500	11,900	11,020	8,850	16,600	880	9,975	547,000	3,515	212,000
10,000	1,500	4,000	1,200	405	12,500	139	670	93,000	700	200,000
0	0			350	0	705				
108,000	7,100	32,100	44,271	50,686	118,800	16,521	52,805	5,180,000	17,772	2,736,500
0.35	no	0.54	0.6	0.37	no	0.44	0.57	0.25	0.74	0.25
		0.17	No				0.1		0.05	
(to Rt. 158) 38,000	7,100	14,300	26,500	18,750	118,800	7,269	27,000	1,295,000	12,500	684,000
2.21	0.85	1.9	5.7	1.45	1.48	1.11	4.9	0.83	6.9	0.92
1,412	543	1,187	3,675	925	946	682	3,125	531	4,448	588
		6.9	12.8				13		6	
		14.6	27				27.5		12.8	
		11,100	20,600				21,000		9,600	
		23,500	43,600				44,300		20,600	
				0.9	0.87	0.9				
(@ Rt 158) 38,000				16,875	97,300	6,570				
95	aerated 110			60	55	50				
18.4	3			12.9	81.4	6				
29,679	4,800			20,800	131,300	9,700		2,000,000		1,000,000
				1,875	21,500	700				

-Figure 19-

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Watershed Erosion and Sedimentation Inventory Procedure

I. Introduction

A. Purpose

- To estimate suspended sediment load at outlet of watershed
- To help determine highest priority watershed for future work
- To gather information in a manner that is both cost- and time-effective
- To create statistically reliable data that will allow all land users to better manage their land for future generations

B. Level of Detail

- Determined by scale and intensity of project
- Match detail to actual need within the watershed

C. Evaluation Criteria for natural conditions or processes that are difficult to quantify with hard numbers

D. Limitations of the Procedure - NOT a monitoring system and NOT site specific, i.e. will not pick out every eroding streambank in the watershed

E. Results (Product) - Predicts average annual rates

II. Background and General Procedure

A. Rapid Assessment, Point Method (RAP-M) - allows for measurement of current conditions in selected statistically valid sampling units and then projects this data to entire watershed

B. Consistency is the key! Follow same procedures throughout each individual watershed for each method

C. Overall sampling unit selection

- Random stratified sampling procedure
- Sampling units of 160-acre blocks

D. Gross Erosion totals - need acreage totals for each major type of land use and slope group class (A and B slope, cultivated) vs. (C+ slope, cultivated)

III. Erosion

A. Sheet and Rill - RUSLE procedure (USLE in woodland, urban areas)

- Apply to each land use type
- Determine rates of erosion
- Apply rates to total acres of each land use type to give overall sheet and rill quantity
- Expand from sample areas to represent entire watershed

B. Ephemeral - in-field measurement or estimated as percent of sheet and rill erosion

- Procedure developed years ago now in FOTG
- Use same 160-acre sampling blocks
- Determine rates of erosion
- Expand these rates from sampled areas to represent entire watershed

C. Gully - use Lateral Recession Rate method

- Randomly selected gully reaches within the 160-acre sample units
- Determine rates of erosion per foot of linear gully
- Measure total gullies in the selected 160-acre sampling units - expand this measurement to entire watershed
- Use erosion rate and total miles of gullies to determine erosion for the watershed

D. Streambank - use Lateral Recession Rate method

- Randomly selected streambank reaches of approximately one-quarter mile in length
- Determine rates of erosion per foot of linear streambank
- Use aerial photography to locate eroding reaches of streams
- Measure miles of streambank within the watershed
- Apply erosion rate to number of miles to arrive at streambank erosion total for the watershed

E. Other

- Shoreline - use Lateral Recession Rate or actual measured quantity, project for the entire lake shore
- Roadside - only used in areas undergoing recent construction activities

F. Gross Erosion - Gross erosion for entire watershed is summation of all the above totals

IV. Sedimentation

A. Sediment Delivery Rates (SDR)

- Each type of erosion produces sediment, but each also produces differing amounts
- Sheet and rill erosion has the most variable SDR's due to the laminar or sheet flow
- Ephemeral, gully and streambank erosion are considered different forms of channel flow, with generally greater SDR's but less variability
- The appropriate SDR is multiplied by the total erosion amount for that type of erosion within a given land use to obtain sediment delivered to the field edge and ready for flow into the stream system. (on-site delivery)
- The total of these products give the proportion of the gross erosion in the watershed that is mobile (See page 12 for SDR guidelines)

B. Sediment Transport Factor (STF)

- Each type of stream system transports sediment at different rates. STF estimates off-site sediment movement through different types of stream systems
- STF captures the watershed differences that are NOT associated with cultural activities of man, for example watershed size, drainage density, stream gradients, etc.
- If SDR totals are summed and multiplied by the STF, the total suspended sediment load at the watershed outlet is determined (See page 13 for STF guidelines)

-Figure 20-

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Level of Detail for Erosion and Sedimentation Studies -Illinois-

Level of Detail	Purpose	Procedures Used	By whom	Time Involved
Level 1 (General)	Overall view of eros/sed in large w.s. > 100,000 ac <u>or</u> smaller ones where only <u>magnitude</u> of loss needed	Map work Use similar watershed 1 SDR /erosion type 1 STF /watershed Generalized assumptions	FO staff RSS ENG	Office: 90% Field: 10%
Level 2	**RAP-M** ***(Simplified Version)***	Use average S & R /land use Measure Ephemeral in field Estimate Gully/Stream erosion by watershed type	FO staff RSS ENG	Office: 80% Field: 20%
Level 3	Determine eros/sed at level necessary for Planning and selecting Alternatives to observed watershed problems - PL 566 - Project-neutral Planning **- RAP-M <u>Plus</u>** ***(Detailed Version)***	Use ave. S & R rates/land use Ephemeral measured in field SDR's for S & R calculated in field Gully/streambank sampling - set up 5-20% sample Can use multiple SDR's	Sed. Specialist	Office: 40& Field: 60%
Level 4 (Very Detailed)	Detailed enough for engin. determinations regarding sediment storage. Generally small subwatersheds.	Measure S & R in watershed Measure Ephemeral in field Walk ALL gullies/streams Calculate SDR for S & R in field. Use multiple SDR's Sediment source analysis	Sed. Specialist	Office: 20% Field: 80%

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Example Sediment Report Using RAP-M Inventory

LAMOTTE CREEK INVESTIGATION CONDUCTED

An erosion/sedimentation inventory was conducted for Lamotte Creek watershed in Crawford County. The watershed totals approximately 15,390 acres or about 24.0 square miles. Sediment Delivery Rates (SDR) for each type of erosion occurring within the watershed and a Sediment Transport Factor (STF) for the entire watershed were also calculated. The main goal was to estimate total suspended sediment load at the mouth of LaMotte Creek where it flows into the Wabash River. This sediment load is considered to be an **average annual rate**.

Surficial geology in this watershed is somewhat variable. This watershed is in the Till Plains Section of the Central Lowland Province physiographic area. Within the Till Plains Section it is considered to be in the Springfield Plain. What these designations allow us to do is group soils and landscapes that are similar and make more generalized, regional statements. In most areas, Peoria Loess (Wisconsin) overlies diamictons (glacial till) of the Glasford Formation (Illinoian) that is generally loam, clay loam or silty clay loam in texture. The thickness of this loess is variable, with depths ranging from less than 2 feet thick to greater than 5 feet thick. This till unit has been named the Vandalia Till and underlies much of southeastern Illinois. Stream dissection has also exposed the underlying Pennsylvanian-aged shale in a few areas. The major stream valleys are composed of deposits of Cahokia Alluvium (old) that is generally less than 20 feet thick. Shale bedrock is below this alluvium on the major valleys, but glacial till can be below the alluvium on the upper reaches of the streams or where smaller tributaries join the main drains as they exit from the surrounding uplands. In the north-central and northeast part of the watershed, loamy and sandy surficial units, designated as the Henry Formation, are present that are stream and terrace deposits laid down by the Wabash River during the Wisconsin time period. On the steeper slopes, especially in the western and southern part of the watershed, the glacial till is the surface unit, with the loess having been truncated. Soils mapped in this watershed reflect the parent material differences discussed above. The surface texture of the soils in greater than 70% of the watershed is a silt loam, reflecting the characteristics of the loess cover that blankets nearly the entire region. This material is quite erosive and is easily removed if exposed to running water. Soils having fragipan characteristics are scattered throughout the watershed, and can be quite erosive if occurring on gentle slopes. The alluvium in the streambanks can contain a variety of materials with a variety of textures and grain size content. Stability of the streambanks is greatly dependent on the shear characteristics of the material, and on a watershed scale, it is difficult to make "general" statements about overall conditions. Site specific determinations are essential for future streambank stabilization activities.

The entire watershed was divided into "pieces" to analyze. To do this, three Geomorphic Units (GU) were set up. These Geomorphic Units are simply landscape units that are similar in geology, slope, soil, etc. and in anticipated response to erosion. These units are: **GU1**, Major floodplains and large wetlands (sinks); **GU2**, Upland flats and depressions with slopes generally 5% or less; **GU3**, Upland, sloping areas, with slopes generally greater than 5%. Each GU produces differing sediment amounts depending on dominant erosion within it. Some, as in GU1, serve more as sediment "sinks" or deposition areas than they do as "sources" or eroding areas. Within GU2, there are a few areas that literally produce no sediment that will impact a surface water body. These areas are called Areas-of-No-Significant-Sediment (ANuSS). Generally, they are relatively flat or even depressional areas of less than 2 percent slope that are not impacted by run-on water, and are more than 2,000 feet from a concentrated flow area (waterway, ditch, gully). These areas have a very low priority for watershed land treatment, in regards to affecting water quality at the outlet.

At least five different types of erosion can produce sediment: sheet, rill, ephemeral, gully, and streambank. In the LaMotte Creek watershed, sheet and rill erosion values were computed from data gathered during the Erosion and Sediment Inventory. In NRCS, we use a process referred to as the Rapid Assessment, Point Method (RAP-M) to statistically estimate erosion and sedimentation rates within any given watershed by sampling a portion and then expanding this data to fit the entire watershed. A Random-Stratified Sampling Procedure was used to select areas to be sampled. Generally, these units were 160 acres in size, and were selected throughout the watershed, with an attempt to characterize all different land uses that are present. Inventory data collected in the field from these sites includes all information necessary to compute sheet and rill erosion losses. Using this data, an **annual** soil loss rate for each type of major land use within the watershed was determined. If the total number of acres for each land use is multiplied times this rate, a gross amount of sheet and rill erosion occurring within the watershed can be estimated. From these same 160-acre sample units, ephemeral gully and "classic" gully reaches were also selected, again using a random procedure.

Ephemeral or "annual gully" erosion was evaluated in the field by either actual measurement of area voided or by applying a standard formula to estimate the total erosion produced on an average **annual** basis. The rates produced using these methods were then projected and expanded to fit the rest of the LaMotte Creek watershed.

Gully erosion ("classic gully" or "perennial gully") was measured in the field within the above mentioned selected sample units. A selected number of the gullies were walked and in-field measurements were made on both the left and right banks in regard to severity of erosion or deposition. An erosion rate, called a "Lateral Recession Rate", was applied to each measured section. These values were summarized and combined to produce an **annual** rate of erosion in tons or pounds of soil material removed per linear foot of gully. The estimated feet of gullies per sample unit was obtained by map wheel measurement from 7.5 minute quadrangle maps, with in-field checking and verification. This value was then expanded to fit the watershed, by first determining which GU unit is most affected by this type of erosion. In LaMotte Creek watershed, GU 3 contains virtually all of the "classic" gullies. So, this unit will represent the entire watershed.

Streambank erosion, the final type of erosion measured, was calculated in a manner very similar to that used for the gully erosion. Selected segments of the main creek and all of the major tributaries were walked. In general, if the selected reach represents a perennial water body (solid blue line on quad map), it was called a "stream"; if it was intermittent (dashed blue line) with a flood plain, it was also called a "stream"; other concentrated flow areas were designated as "gullies." By measurement, approximately 26.9 miles of perennial streams exist within the total watershed. Of this total, approximately 11.6 miles are from the main channel of LaMotte Creek itself. The rate of streambank erosion was calculated exactly as it was done for the previously mentioned gully erosion, using slightly different qualitative parameters and then summarized. Using the measured rates of streambank erosion and the map measured miles of streams that are currently eroding, an estimate of the quantity of erosion taking place was obtained.

In a dynamic environment that is constantly adjusting to man-made and geologic conditions, gullies and streams (as well as all other landscape characteristics!) are in a perpetual state of shifting between downcutting and deposition. During field measurements, an attempt was made to verify the overall general percentage of gullies and streambanks eroding or, if possible, changes in these percentages based on landforms, soils, etc. If this field-verified value was significantly different from that percentage arrived at from the sample inventory, then a slight adjustment was made in the overall rate of gully erosion to account for this.

SHEET AND RILL EROSION in LaMotte Creek

Sheet and rill erosion occurs on all land whether it is cultivated or not. It is a very natural, unending process. It is more of a concern when it is accelerated by man's activities. In the LaMotte Creek watershed, sheet and rill erosion was estimated, on a per acre basis, for all the dominant land uses. For cropland, evaluations were made for both the "A" and "B" slope areas (0 to 4%), for the "B2" areas with slopes up to 5% and moderately eroded, and for the "C" slope and greater areas (5%+). Average rates of soil loss for A/B slope areas were 2.4 T/A/year. For B2 slope areas, the rate was 5.3 T/A/year. For C slope and steeper areas of cropland, soil loss was 8.5 T/A/year. In this watershed, land currently in CRP was still considered to be Cropland, and was included in the above appropriate category.

Areas of woodland were grouped together, regardless of slope, and had an overall rate of erosion of about 0.6 T/A/year. This included a few areas that had been grazed in the past but now were relatively undisturbed. Pastures and other grasslands were grouped regardless of slope because there were only a small percentage of fields that fell into this category. The average soil loss on these areas was 1.9 T/A/year. "Urban" areas in this watershed consisted of farmsteads, roads, feedlots, city parks, and a few other areas, of all slopes. Soil loss from these areas was low, with an average annual rate of 0.8 T/A/year. The only other type of land use considered in this watershed was Wildlife Land, which consisted of land of all slopes that was brushy or otherwise unmanaged for anything else. It was generally moderately rolling to steep and had an average annual soil loss rate of 0.5 T/A/year.

Total sheet and rill erosion from **cropland** is estimated to be 37,310 tons per year. This figures out to be about 3.2 T/A/year for all cropland. Sheet and rill erosion from pasture and grassland is about 1,170 tons per year, with woodland areas producing about 920 tons per year. Rural "urban" areas produce only about 620 tons of erosion per year and Wildlife Land about 310 tons per year. **Total sheet and rill erosion** in the LaMotte Creek watershed is estimated to be 40,330 **tons per year**. This is roughly 2.6 T/A/year for each acre of land in the entire watershed.

EPHEMERAL EROSION in LaMotte Creek

Ephemeral erosion occurs when tiny rills coalesce into small channels that tend to "funnel" water in a concentrated flow. These ephemeral, or "annual" gullies, are usually destroyed each year as the tillage for the year is completed. However, if the rate of erosion is great enough, the small channels will enlarge, even in a year's time, to concentrated flow areas that are too large to be crossed with normal tillage implements. This, then, becomes the beginning of the more "classic" perennial gully. These ephemerals generally begin to form where relatively "flat" or gently sloping soils "break" into steeper areas. Often times, they form on the edge of cultivated fields where the native vegetation is no longer in place to hold the soil during the higher flow times. In the past couple years, more emphasis has been placed on attempting to measure the amounts of erosion from these gullies. Studies have indicated that in some states, these contribute as much erosion, and thus sediment, as does sheet and rill erosion. For this field study, the length and grade of each ephemeral, and the type of tillage surrounding each of these was recorded. This information was then plugged-in to a predictive formula that has been developed to estimate tonnage of erosion, assuming one annual voiding. In this watershed, approximately **8,500** tons of erosion can be contributed to the **ephemerals**.

GULLY EROSION in LaMotte Creek

Gully erosion was estimated in the entire watershed by selecting random "reaches," evaluating these "qualitatively" to obtain "quantitative" values, and then "expanding" this data to fit the remainder of the watershed. The premise for this is that if enough segments are sampled, areas that are only slightly eroding as well as those that are very severely eroding will be selected to evaluate. This percentage then, can be used throughout the watershed with statistical validity. The "qualitative assessment" used to assign Lateral Recession Rates is one that bases observed physical features of the gullies with actual measured amounts from many Midwest watersheds. In LaMotte Creek, many gullies contained "knickpoints," or small overfalls in the base of the channel. This can indicate recent downcutting and also indicate a difference in soil material. In areas where loess overlies glacial till, a whole series of these knickpoints can be traced up many of the gullies. In regard to sediment production, each type of material produces different rates **-** the loess is most susceptible and will readily collapse into the gully and be moved off-site. The glacial till has more strength and is more difficult to erode, but can be eroded over time. Glacial till generally contains the large stones and much of the sand and gravel that is observed in the streambed farther down. With the degree of dissection present in this watershed, the erosion produced by eroding gullies can become significant quickly. In LaMotte Creek watershed, approximately **6,000** tons of soil is eroded each year that can be attributed to **gullies.**

STREAMBANK EROSION AND SEDIMENTATION in LaMotte Creek

Streambank erosion in any watershed is a rather complex and detailed process. As the stream meanders across its valley or floodplain, "new" sediment is being added continually as the stream cuts into its banks. However, sediment is also being deposited in perhaps another portion of the stream as energy levels of the stream rise and fall. If the "net effect" remains somewhat constant over a period of years, the stream is considered "stable" and the changes are considered to be part of a "dynamic equilibrium" condition that exists within the watershed. If, however, this ongoing process is skewed one way or the other and either severe downcutting and bank caving predominates or extreme rates of sedimentation within the stream are occurring, then it is considered to be "unstable." In truth, many streams experience all of this variation if all stream reaches from headlands to mouth are considered. To determine the magnitude of the dominant process occurring, then, the stream itself must be walked and evaluated. In most cases, no other "measured" streambank data has been gathered in the past, so these **estimates** become the base for determining present sediment yield and future projections that would be modified by treatment measures in the watershed.

The field data collected by NRCS staff conducting the Streambank Inventory, contained estimates of Lateral Recession Rates (erosion rates) that ranged from "slight" (0.03 of a foot per year) up to "very severe" (3.0 feet per year) of actual bank recession. These estimates could underestimate the erosion amounts coming from the most severely eroding sites. It is assumed that on every stream reach in Illinois the "slightly" and "moderately" eroding areas probably contribute very small amounts of sediment to the overall average annual yield. This has helped to bring these more in line with actual measured values.

In this inventory and using NRCS methods of "visual assessment," an overall rate of streambank erosion, on an **average annual basis**, was calculated for LaMotte Creek and several of the major tributaries. The average annual recession rate calculated for LaMotte Creek and its tributaries was 53 pounds of soil per linear foot of streambank. Using this rate and the known length of perennial streams in the watershed, total **streambank** erosion is estimated to be **3,760** tons, which is considered to be an **average annual rate.**

SEDIMENT DELIVERY RATES (SDR) and SEDIMENT TRANSPORT FACTOR (STF)

Only a portion of the sediment produced reaches a concentrated water source. Then, the stream system itself transports only a portion of what actually enters it. To account for this, Sediment Delivery Rates (SDR) and Sediment Transport Factors (STF) are used. These factors are similar to the Blue Book value of a used car **--** for a car, start out with a base value and then add or subtract from that, depending on the options and mileage on the car. For this watershed, start out with a "standard" value and then adjust this number up or down based on landscape characteristics. The LaMotte Creek watershed is somewhat complex when it comes to overland flow of water and sediment. It is a mature watershed, geologically, with an abundance of short, steep slopes along the major drains but longer, more gentle slopes away from the drains. Stream dissection and downcutting is quite evident in some parts of the watershed. What this means is that some of the sediment moves just to the base of the slopes while other sediment may move entirely through the watershed.

SDR's vary for each type of erosion, as would be expected. Sheet and rill erosion and the sediment it produces varies dramatically across this watershed. In the area surrounding the main LaMotte Creek segment and the other major tributaries, sheet and rill erosion potential is greatest. The land is more sloping and the slopes are often short and "choppy." Conversely, in the areas of the watershed where the slopes are longer and more gradual or the land is nearly level, the soils do not have a high erosion potential. Along the path to a concentrated water flow area, many options are available for the sediment. Small sinks or traps are found within this watershed and include potholes, small ponds, wetlands, and even the flat parts of upland fields. In many cases, the wide floodplains can serve a very natural and useful purpose by also keeping sediment from entering the streams. Some of these "local" sinks effectively capture nearly 100% of the sediment produced above them in their subwatershed.

SEDIMENT DELIVERY RATES in LaMotte Creek

Sediment Delivery Rates (SDR) are used to predict the quantity of sediment that is moved “on-site” to be “available for transport.” For example, sediment is produced on a sloping, cultivated field each year as the farmer chisel plows the field. The sediment moves down the slope, and here, some of it becomes immobile as it imbeds itself within the grass or is deposited where there is a change in slope. Some of it, however, is in a position near a waterway, or ditch, or shallow field channel that makes it available to move farther with the next storm event. SDR’s are developed for each type of erosion and often times, several are developed for sheet and rill erosion, based on where the slopes are within the watershed.

Sheet and rill erosion has the most complicated Sediment Delivery Rate, because it involves sheet or laminar flow, as opposed to channel flow. Some of the factors involved in determining this are land slope, distance from a concentrated flow area, slope configuration, NRCS runoff curve number, and a surface roughness coefficient. Usually a “base rate” is determined for the conditions in the watershed or subwatershed, and then adjustments are made to that rate based on subsidiary conditions. A strong attempt is made to apply these criteria in a uniform and consistent manner throughout. Since sheet and rill erosion from the cropland areas was so varied, due to slope and land use, no single value of SDR seemed to suffice. For cropland areas, three different SDR’s were used, generally based on whether the soils were less than or greater than 5%. For pastureland and grassland, only one SDR was used. Woodland was the major land use along some of the main stream tributaries and was comprised of those areas that were relatively undisturbed and those areas that had been grazed in the past. Also, a range of slope phases were included within this category. Because of this variation, only one SDR was applied. Wildlife Land also was composed of a variety of slopes and ground cover conditions. Only one SDR was used here. Finally, “urban” areas also had a separate SDR applied because the close-cut lawns, feedlots, city parks, etc. causes transport factors to be significantly different than cultivated fields. The different SDR’s used in this watershed for sheet and rill erosion ranged from 0.11 to 0.60.

Ephemeral, gully, and streambank erosion are all considered to be a form of “channel” erosion which have larger SDR’s because often times the erosion-produced sediment comes from the channel bottom and sides themselves, therefore naturally being more directly tied to delivery into the stream system. Ephemeral SDR’s commonly are in the 0.75 to 0.85 range. In the LaMotte Creek watershed, a value of 0.70 was used for all the ephemeral erosion sediment routing purposes.

Gullies serve as almost the “perfect funnel” to move sediment directly into the entire stream system. Gullies that lie immediately adjacent to the main channel have SDR’s of 0.90 to 1.0. Gullies that occur on the extreme upper reaches of the watershed may have a range of 0.70 to 0.90. In this watershed, a rate of 0.75 was used for all the gullies.

Streambanks, of course, have an SDR of 0.95 to 1.0. Literally everything that is eroded from the streambanks falls in the stream and is immediately available for transport. This is one of the reasons that even though the quantities of sediment produced by streams is not as great as compared to some of the other sources, it is literally 100% “delivered.” Sheet and rill produces large quantities of erosion and sediment, but only a fraction of it actually enters the system. Therefore, it is often times more important to treat the streambank areas because the sediment is much more “concentrated” and can often be considered a “point” source of pollution.

SEDIMENT TRANSPORT FACTOR for LaMotte Creek

Sediment Transport is the final step in our erosion/sediment cycle. Sediment Transport Factors (STF) attempt to rate the overall effectiveness of the entire stream system in moving sediment through. Stream systems that are relatively small, have high gradients, and have small tributaries that reach to almost all the segments of the uplands move sediment through much more completely and rapidly than ones that are quite large with numerous locations for sediment to drop out, have low stream gradients, and have numerous undrained upland areas. The STF is based on several factors, including drainage density, drainage texture, relief/length ratios, valley slope of 3rd order streams, size of the watershed, type of sediment that is predominant, percent of the watershed “controlled” by natural or man-made “sinks,” stage of stream system development, etc. These factors are weighted and then applied to the stream system in as uniformly and consistent manner as is possible. The number produced by the rating system is simply multiplied times the total sediment “available for transport” and this number is then the total sediment, from all sources, delivered to the Wabash River. For this watershed, a STF of 0.57 was used for sheet, rill, ephemeral, gully and streambank erosion.

SUMMARY OF EROSION AND SEDIMENTATION IN LAMOTTE CREEK WATER SHED

In LaMotte Creek watershed, an estimated **58,590 tons of erosion** occurs on an annual basis from the five major types of soil erosion. If this number is divided by the number of acres in the watershed, a rate of about 3.8 tons per acre per year is obtained, when ALL sources of erosion are considered. Of this total, approximately **12,900** tons of **sediment** is actually "delivered" to the outlet end of the watershed at the Wabash River. This gives an overall rate of 0.8 tons per acre per year or 512 tons of sediment per square mile of watershed. At 50 pounds per cubic foot for submerged (saturated) sediment, this also calculates to be 11.8 acre-feet of sediment deposition on an annual basis.

Roughly 38% of the sediment comes from sheet and rill erosion and 26% from ephemeral erosion (channel). Gully erosion (channel) contributes about 20% and about 16% comes from streambank erosion (channel). Remember, though, that sheet and rill sediment comes from all 15,390 acres of the watershed, while the streambank sediment comes from only about 26.9 miles of stream, of which less than one-third of the total mileage is producing nearly three-quarters of the total load. Likewise, there is still much discussion on SDR rates for slopes less than 5%. It is believed presently that SDR **base rates** of 0.10 to 0.15 may be more appropriate.

Bedload material is very seldom measured as an output at the point of delivery, because of the cost and extensive sampling equipment that is necessary to complete this job. USGS gage stations do not routinely sample or measure this material. General estimates can be made, based on suspended sediment quantities. In Illinois, estimates of 5 to 10 percent of this total can be used. In this case, then, using NRCS methods, roughly 645 to 1290 tons could be added to the total suspended load delivered of 12,900 tons. In most cases, bedload type, composition, and grain size coming from the streambanks and streambeds, is used extensively in channel design and channel geomorphology studies but is not routinely reported.

Assessing the overall "dynamic equilibrium" stage in a watershed is most difficult indeed! In other words, is the stream system still degrading or has the sediment production in the watershed reached a peak and now will begin to decline?! Years ago, several geomorphologists developed a landscape model called the Channel Evolution Model that was intended to determine the relative differences between gullies/streambanks that were progressing from a "stable" condition, Stage 1, through a series of "unstable" steps to a new, but geologically lower "stable" condition called Stage 5. This process can take decades or several millennium. LaMotte Creek is definitely undergoing incision or downcutting in many of its tributaries (Stage 2). As long as downcutting is occurring, continual amounts of sediment will be produced. This rate of sediment production will only begin to decrease when the streams reach a condition of bed stability that will in turn allow the streambanks to stabilize (Stage 4). Watershed efforts can assist this progression, but total watershed stability is a long way in the future!

SUGGESTIONS FOR EROSION AND SEDIMENT CONTROL

1. For the most effective land treatment control, concentrate any land treatment alternatives on the sloping (>5%) areas that lie immediately adjacent to the channels or streams themselves . In other words, because the "flat" land doesn't really produce much sediment that reaches the Wabash River, it is not necessary to spend unproductive time and effort in these areas.

2. If needed, select a "pilot" subwatershed and concentrate land treatment or structural control efforts here. From this "base" a better estimate as to effectiveness of these controls could be made for the remainder of the entire watershed. These smaller subwatersheds also give the local people a better visual example of how their erosion control methods will work.

3. Select highly visible or locally “known” eroding sites for demonstration areas, particularly if streambank stabilization is included as part of the project. It will be easier to point at these to demonstrate how effective local efforts have been.

4. If structural measures are used in the watershed, it is important to remember that they generally will “control” the **sediment** produced from **all types of erosion** above them in their subwatershed. This is an important point from a watershed management perspective: structures control sediment more so than erosion. What does this mean? If a structure (WASCOB, pond, dry dam, etc.) is placed in a drainageway and surface water runs into it or through it, a sediment reduction will occur due to the trapping efficiency of the water pool. The surface water might be carrying sediment derived from sheet, rill, ephemeral, and gully erosion, but much of the suspended and nearly all the bedload is trapped, regardless of the source. These small structures will also dramatically reduce the peak runoff flows developed during rainfall events. The magnitude and timing of these peak flows can significantly affect channel erosion and overall movement of sediment within a given subwatershed. In general, it is more efficient and effective to have these structures as “low” in the watershed as is possible. The more of a subwatershed that occurs above them, the greater the amount of the runoff and sediment that is “controlled” or “captured.” A word of caution: When dealing with “cleaned” water, if the water channels are silts and fine sands, the additional energy of “clean” water can lead to accelerated channel erosion below these structures. Stabilization and sediment reduction must always be handled in combination during any engineering design.

5. Streambank stabilization projects “attack” localized sediment production directly. However, streambank projects do not deal with reducing sediment already in the stream system from other upland sources. Therefore, it is important to remember that, in general, the entire watershed must be “treated” to effectively reduce the overall sedimentation rate.

6. If significant land use changes are anticipated in a certain segment of the watershed, these areas should probably be “monitored” more closely because of the potential for more rapid change in sediment rates. Even relatively small areas can significantly increase the sediment load on the stream system or subsystem.

7. Structural means of sediment control have been effective on smaller watersheds, utilizing time-tested measures, such as WASCOB’s, dry dams, ponds, etc. Do not overlook these but always be on the lookout for new, innovative ideas and methods that can be applied **in** the watershed. Streambank stabilization methods are being developed and perfected in each new watershed they are used in. Progress is being made!!

8. One of the “new” (experimental??) methods referred to above would be the use of off-channel wetland diversions. These could allow for surface water from the creeks that exceeded a certain designated discharge to flow into a wetland area that was immediately adjacent and parallel to the stream. Water that has time to slow down will begin to drop a certain proportion of its sediment load. Even small amounts of deposition 20 to 40 percent of the total suspended load--could have a dramatic influence over the entire watershed.

BATHMASTER

A System for Real-Time Depth Mapping of Lakes, Ponds and Reservoirs

R. D. Windhorn
T. D'Avello
2/01

NRCS Bathymetric Mapping in Illinois

NRCS (known formerly as SCS) has a long history of conducting in-lake sediment surveys both in Illinois and nationwide. A national policy has been in place since the 1940's requiring that reservoir sedimentation rates be monitored, especially on those water impoundment structures that NRCS (SCS) had a part in constructing. Many of the reservoir sedimentation computation formulas used today by engineering firms, Illinois State Water Survey, and others were developed by SCS engineers and geologists. Information gathered from these surveys has improved the designs of structures and allowed for longer lives of these structures, which is more economical for all concerned.

Nearly all of these measurements were conducted by physically probing the bottom of these reservoirs either from a boat or through the ice along established transects. Monumented, permanent abutments were established on the banks of the structures, from the dam all the way to the upper reaches of the permanent pool, and then nylon rope or steel cable was stretched across the lake from one monument to the other. On a periodic basis, the entire survey was set up and run again, and changes in the volume of accumulated sediment allowed for calculating rates of reservoir sedimentation.

In the last 10 to 15 years, the frequency of these studies has been reduced significantly across the United States. Increased use of water bodies for recreational use has severely limited the window of opportunity for conducting the surveys, especially on those lakes that do not freeze solid in the winter. In the mid-1990's, NRCS simplified the process. With the advent of Global Positioning Systems (GPS), laptop computers, and more sophisticated software, NRCS was able to set up and test bathymetric methods to calculate sediment volumes by plotting the current bottom of these lakes using fathomometers and real-time GPS.

After developing a prototype method, an effort was made to find lakes in the state that could be used to test the system. Generally, the local NRCS or SWCD office chose these lakes. Adjustments were made from these early mapping attempts and, in some cases, results were compared to measurements made in a similar fashion by another agency or by NRCS at an earlier date. As more experience was gained and more people heard about the method, increased interest led to a loose policy on how this technology would be applied in Illinois:

The intent of this technology is *not* to replace surveys conducted by engineering firms or others who rely on this type of work for a career. It is *not* to be offered to private individuals or organizations as a free sediment survey. It is *not* to be used by local officials as a bargaining tool in dealing with Illinois State Water Survey, private engineering firms, etc. to obtain a better deal. It *is* meant to be used 1) as a way to gather current sedimentation information that can once again be provided as part of the National Cooperative Sedimentation Survey and 2) as a resource planning tool to gather information on erosion and sedimentation in a watershed that will allow the local landowners the opportunity to reduce erosion rates and to improve water quality. The work will all be set up and conducted at the request of and through the local NRCS/SWCD office or possibly through the FOD engineer who has worked with the same clients. No direct-contact requests will be serviced. If the local NRCS does not currently have and does not intend to have plans to work with the requesting individuals in the immediate future, *no NRCS sediment survey will be conducted.*

Getting Started

Purpose

To map the current depth of lakes and reservoirs and measure sediment to estimate original depth and sediment accumulation in support of watershed planning activities.

History of Sediment Surveys

In-lake sediment surveys have been conducted by NRCS for a number of years to both monitor PL-566 projects and to contribute to the National Sedimentation Study. These traditional methods involved sampling along cables suspended from permanent concrete monuments and stretched across the lake. These surveys were time-consuming and required a large number of individuals to complete. Several small boats were necessary, as was surveying equipment. The ropes or cables used were subject to stretching and caused logistic problems if stretched across boat-busy sections of a lake. These surveys were also limited to small and moderately sized lakes, due to the physical limitations of stretching cable or rope an extended distance. Sediment and water depth sampling at designated points along the cable was dependent on the stability of the boat used and the skill of the boat operator in keeping the boat from excessive movement. A limited number of points could be sampled as the cost per sample was high.

New Needs

In Illinois, there is now an increased demand for sediment information on lakes of all sizes. The increased boat traffic on many lakes also made it necessary to measure sediment in an easier, quicker, safer, less time-consuming, less personnel-demanding, and less costly manner than traditional methods. The use of Global Positioning Systems (GPS) in support of sediment surveys was initiated in the summer of 1995. This involves capturing the coordinates of each sample point and keeping a record of water depth and sediment thickness for each point. The sample pattern and number of samples that can be obtained are restrained only by time. The point data is input into a GIS, and subsurface elevations are generated. Volumes for both water and sediment are determined from the GIS.

Equipment Used

- 486 or Pentium Laptop Computer with Serial Port PCMCIA Card
- Rockwell PLGR+ Global Positioning Receiver with serial cable
- Sonar capable of outputting NMEA 0183 (In our case, the Lowrance 350C)
  There will probably have to be modification of cabling and port, dependent on make and model of sonar. This information can be obtained from the manufacturer.
- GeoLink XDS (XDS) software and hardware key

Procedure

Pre-Field Procedure

1) Selection of the proper base map is essential. A 7.5 minute quadrangle map supplemented with a recent aerial photo are probably the best choices. This map, in hard copy form, serves as the field guide and is essential for taking field notes. The map also serves as the base for digitizing the lake boundary in a GIS and for use as a background map in GeoLink XDS (XDS). It is important to use the most recent data when digitizing the lake boundary. This usually requires acquisition of current aerial photographs, as most 7.5 minute quadrangles are relatively old. Also, when the lake was originally constructed, it had an initial surface area of a certain acreage. Through time, that original surface area will have been reduced, even though local sources will still quote the documents that claim the lake has a certain surface area. It is important to know, as precisely as possible, the current lake surface area.

2) All of the equipment used in this procedure requires a 12-volt supply of power. It is recommended that all batteries are charged sufficiently before leaving for the field. Also, it is appropriate to carry an additional supply of "AA" batteries. The rechargeable ones work fine, but generally life-span is not as long.

3) If sediment samples are to be selected for lab analysis or for general data collection, the proper sampling equipment must be used. A standard AMC sampling tube with the proper number of extensions works well for small samples or to cross-check sediment depth. An AMC bucket sampler with a butterfly closure may also be used to obtain a sample for analysis. To obtain an undisturbed sample for soil mechanics testing, one may hand-push a 4-inch Shelby tube (or its equivalent). All this equipment and any accompanying tools must be gathered together ahead of time.

4) This procedure measures water volume in the lake at the current time. Sediment volume is estimated by comparing the current volume of water to the volume at the time of construction. Several reliable sources may be used to obtain the initial volume. The best source is the volume estimated from the original cross-sections during construction of the lake. If these are not available, the national Dams Inventory will provide an estimate. If that estimate is not suitable, several state agencies publish estimates used for their own work, such as evaluating fishery habitat, etc. Unfortunately, these estimates very seldom agree.

5) The current lake level elevation must also be determined. The easiest way is to take the elevation of the principal spillway from the most up-to-date quadrangle map. If the year has been particularly dry, however, this elevation may not reflect the most accurate estimate. The local water plant often monitors the lake level on a daily basis, and this would be the best place to obtain an accurate lake level.

6) As soon as a particular day has been selected to run this survey, research the availability of satellites throughout the day. To do this, run a Number Svs and PDOP to determine if there are bad spots in the satellite coverage for that particular lake on that particular day. If these bad spots extend through the time planned for the survey, a readjustment in the scheduling is needed. Generally, these poor coverage times exist for a few hours at most and can be avoided, if known in advance.

In-Field Procedure

1) The boat used to conduct the survey does not need to be fancy but must be, above all, stable in the water. A "john-boat" or pontoon boat seems to be the best for this type of survey. In both cases, samples of the sediment can be taken while leaning over the side of the boat without excessive tipping. The motor must simply be large enough to propel the boat at a reasonable speed of 5 to 10 miles per hour. A 15 to 25 horsepower motor is generally a good size. If a much larger motor is used, then it must be throttled-down to the extent that fouling of the plug(s) can occur.

2) Once the equipment is on board, the depth finder should be hooked up first. The transducer is portable. It attaches to the side of the boat with a large suction cup or can be attached to an aluminum downrigger that has been clamped to the side of the boat. Ideally, the transducer should be attached to the boat hull on the side, not the rear. If it is attached too close to the motor, "prop wash" will cause cavitation and the transducer will not produce accurate readings. If mounted on the side of the boat, a deflector shield bolted on to the rail is essential to hold the transducer in place when the waves push against it.

3) With the depth finder in place and giving readings, check the water depth manually with a marked pole or graduated line to determine whether the depth finder depicts the actual water depth. Different mounting locations on the hull can produce different depths. It is a good practice to check or calibrate the depth finder several times over the course of the day.

4) Turn on the GPS unit on-site so that it can acquire satellites. This could take up to 20 minutes, depending on satellite availability and where the GPS was last used. Once four or more satellites have been acquired, the unit can be put in Standby Mode to conserve power.

5) The instrumentation set-up for the procedure is as follows:

Instrument Set-Up

Sonar: Set output depth units to **meters.** Meters are *required* by **XDS.**
Additional settings may be required depending on device

GPS: **Continuous** Mode
Turn timer **OFF**
Coordinate system and datum are controlled by XDS, but we usually set both to agree with the digital "background" data
Standard serial port settings

Let PLGR acquire satellites

Laptop: We use a DOS boot disk with minimal settings to AUTOEXEC.BAT and CONFIG.SYS to insure no background processes interfere with GeoLink. Quicker boot-up is another advantage.

Contents of AUTOEXEC.BAT:

```
PATH C:\DOS;C:\geolink
```

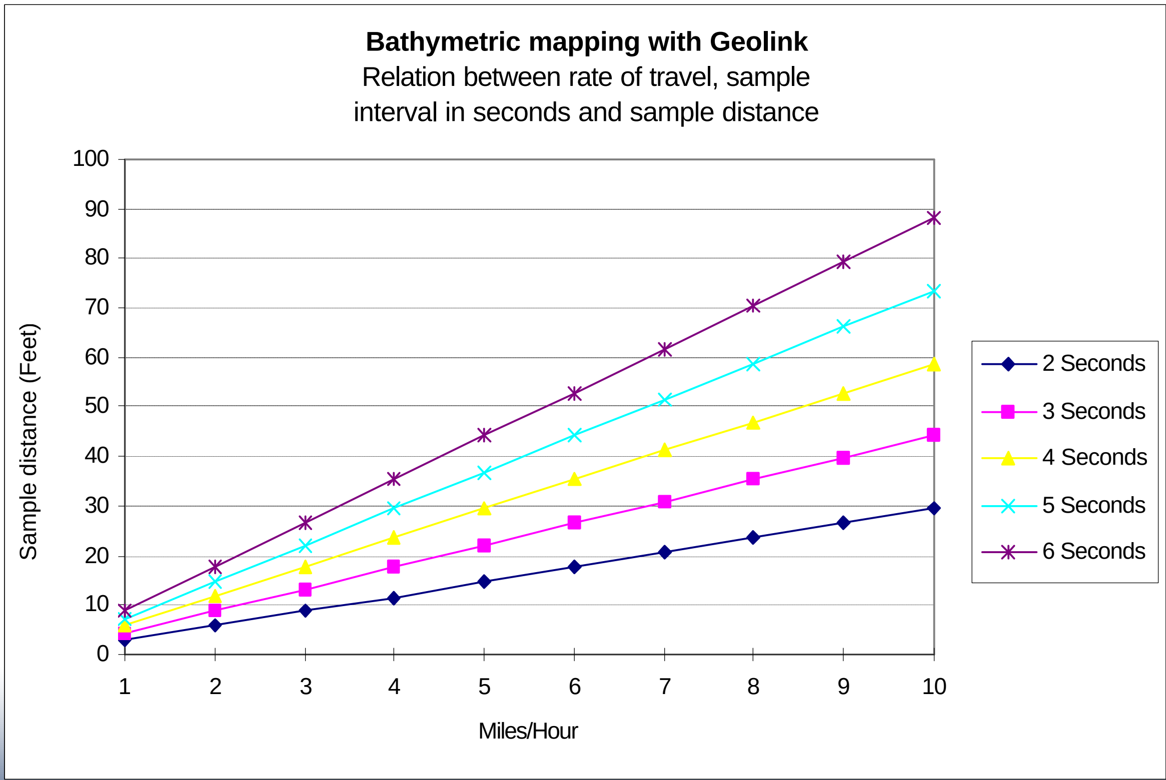
Contents of CONFIG.SYS:

```
FILES=65
BUFFER=10
STACK=9,256
REM LASTDRIVE=J
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\DOS\EMM386.EXE NOEMS X=D000-DFFF
DOS=HIGH,UMB
SHELL=C:\DOS\COMMAND.COM /P /E:1024
REM CardSoft (TM) 3.1 PCMCIA DRIVERS
DEVICEHIGH=C:\CARDSOFT\SSVLSI.EXE
DEVICEHIGH=C:\CARDSOFT\CS.EXE
DEVICEHIGH=C:\CARDSOFT\CSALLOC.EXE
DEVICEHIGH=C:\CARDSOFT\ATADRV.EXE
DEVICEHIGH=C:\CARDSOFT\SRAMDRV.EXE
DEVICEHIGH=C:\CARDSOFT\CARDID.EXE
DEVICE=C:\EPP\EPPDRV.EXE
LASTDRIVE=M
```

Boot-up laptop with boot disk

XDS: Type “glxds” at prompt to start XDS program

Select **SETUP** from menu
Select **Logging**
Select **XDS** format
Select **NMEA**
Select **collection interval**. The following chart is used as a reference:



Instrument Set-Up (continued)

Select **Port for GPS** with following setings

Baud rate = 9600
Parity = None
Data Bits = 8
Stop Bits = 1

Select **Port for Sonar** with following settings

Baud rate = 4800
Parity = None
Data Bits = 8
Stop Bits = 1

Select **Map Ctl**
Select **Background Map File** with corresponding format
Select **Datum & Projection** and select appropriate datum and projection for real-time and background display
Select **Map Width** to adjust map scale, which controls amount of background map displayed at one time
Select **Mode**
Select **View a Map file** and indicate corresponding background map to display
Select **Log to GPS** and enter file name. *Do NOT touch keyboard* during logging session.

Hit **ESC** button on keyboard to end session

If the inventory is incomplete, a new session can be created with a new log file, or the original file can have new values appended to it.

6) Once the instruments have been set up and calibrated accordingly, begin the actual in-lake procedure by the principal spillway, if possible. Oftentimes this is where the boat launching area is located. The sampling process is relatively simple. A random, zigzagging pattern that includes all major bays and inlets is probably the best way. With the outline of the lake displayed on the monitor, it is easy to see where the boat is and what course it must take to read the majority of the lake bottom. Special care must be taken to sample all major sediment-producing streams and inlets so that a true representation of sediment distribution in the lake is possible.

7) It is important to reach as far as possible in to the upper reaches of the lake where large sediment flats may exist. The better the distribution and the greater the number of samples, the more accurate the resulting surface plotted by the software. These relatively shallow flats are often the best places to obtain sediment samples for analyses. A tube can often be pushed into these by hand without falling into deep water.

8) It is recommended, but not required, that the random sampling pattern be concluded near the point of origin. Although this is not essential, it does tend to draw the survey together and helps determine whether all the important areas of the lake have been covered.

9) When the inventory is complete, first remove the transducer disk from the side of the boat. This protects it from damage as the boat enters shallow water near the boat ramp.

10) All data gathered during the inventory and entered into the laptop, should be saved to the document file set up at the beginning of the survey. Make sure all equipment is then turned off and stored inside the “BATHMASTER” box.

Post-Field

1) Any samples that have been collected need to be wrapped and labelled completely. These sediment samples will be saturated, and a waterproof wrap is essential. Oftentimes, smaller samples will need to be air-dried once they are back at the office to make for easier mailing. Any undisturbed samples, however, may need to be retained in their "field" condition.

2) To prepare for the next survey, all batteries should be recharged or replaced as appropriate. All equipment should be cleaned and dried, and all electrical connections should be taken apart, dried, cleaned, and reconnected so that no rust or corrosion can form. It is essential that the laptop is allowed to thoroughly dry out.

Post Processing

XDS creates several files with various extensions which can be used for import into software packages to create surfaces. Typical GIS packages such as Arc/Info and GRASS have several methods available for interpolation of random points into surfaces, as does the software package SURFER, which is not a GIS package, but a specialized surface generation package. The two critical files will have a **.PTS** and **.PTX** extension. If the data will be processed in a Unix environment, run the dos2unix command prior to processing. The contents of the **.PTS** file are: id,x,y and the contents of the **.PTX** file are: id,attribute.

For example

"FILE.PTS"	"FILE.PTX"
1,423000,1700234	1,10
2,423010,1700200	2,12
3,423040,1700180	3,12
., . , .	.,.
.	.
n,x,y	n,attribute

These files can be manipulated to accommodate the import requirements of the respective post-processing software. To ensure a good interpolation, points of "zero depth" should be appended to both the **.PTS** and **.PTX** files. The zero depth points are assumed to be the current lake boundary and can be exported from most GIS packages using the digital lake boundary as a source. The export properties and behavior are unique to each GIS package. Be sure to offset the ids for these points to ensure that all points are unique.

Once imported, creation of an acceptable surface follows. This is typically an iterative process using any number of methods including, but not limited to:

- Inverse Distance Weighting
- Spline
- Kriging
- Triangulated Irregular Network (TIN)

Review of the resulting surface by those familiar with the area is recommended.

Current Volume can be determined most accurately from a TIN model.

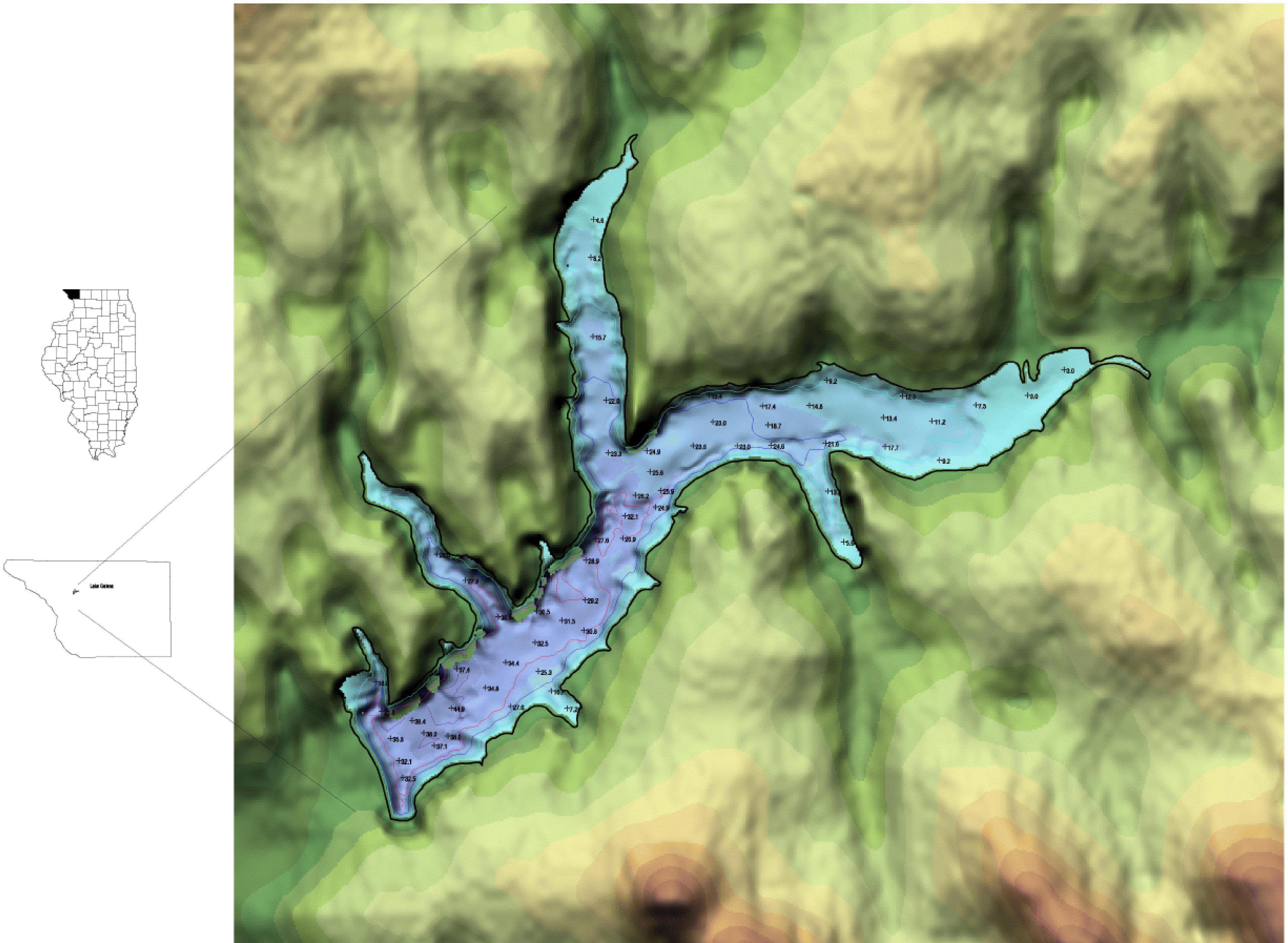
Final Calculation

The above calculations give us a Current Lake Volume, and it is assumed that an Initial Volume, before the dam was closed, was known or predetermined (See **Procedure**; Pre-Field, #4). The difference between these two values should give us a good estimate of the volume of sediment now deposited in the lake.

A yearly rate of sedimentation can easily be calculated if it is known what year the dam was closed and water first started to pool. A per-acre and a per-square-mile-of-watershed rate can be easily calculated as well. Another advantage of this method is that the pattern of sediment deposition in the lake can also be tracked. Sometimes this is almost more important in reservoir management than the actual rate itself.

The accuracy of this method increases when the lake is round or oval with few shallow fingers or long, narrow tributaries in the upper reaches of the lake. These shallow areas trap and hold a tremendous amount of sediment, but are difficult to maneuver in a boat and therefore offer less chance for the software to account for them. Also, some of these areas only contain water during the wettest times of the year. This sometimes leads to questions as to whether or not they should even be included in the reservoir totals.

Finally, any sediment values obtained MUST be checked for “reasonableness.” This method is just another way to estimate a rather abstract value--it is not an infallible procedure! If the estimated rates appear to be too high for the location in the state, soil types, slopes, etc., be sure to validate them! One of the best ways to do this is to compare the rates of sedimentation measured here with the rates of erosion and sediment delivery in the entire watershed. Could the erosion rates predicted actually produce this volume of sediment? If not, then it is necessary to backtrack to discover where the discrepancy exists.



Lake Galena
Estimated Depth

Volume: 6,365 Acre Feet
Maximum depth: 46 Feet

Input values determined from Lowrance 350LS Depth Finder, sampled June, 1999.
Volume and contours derived from TIN model developed in Arc/Info 7.1.2.

N

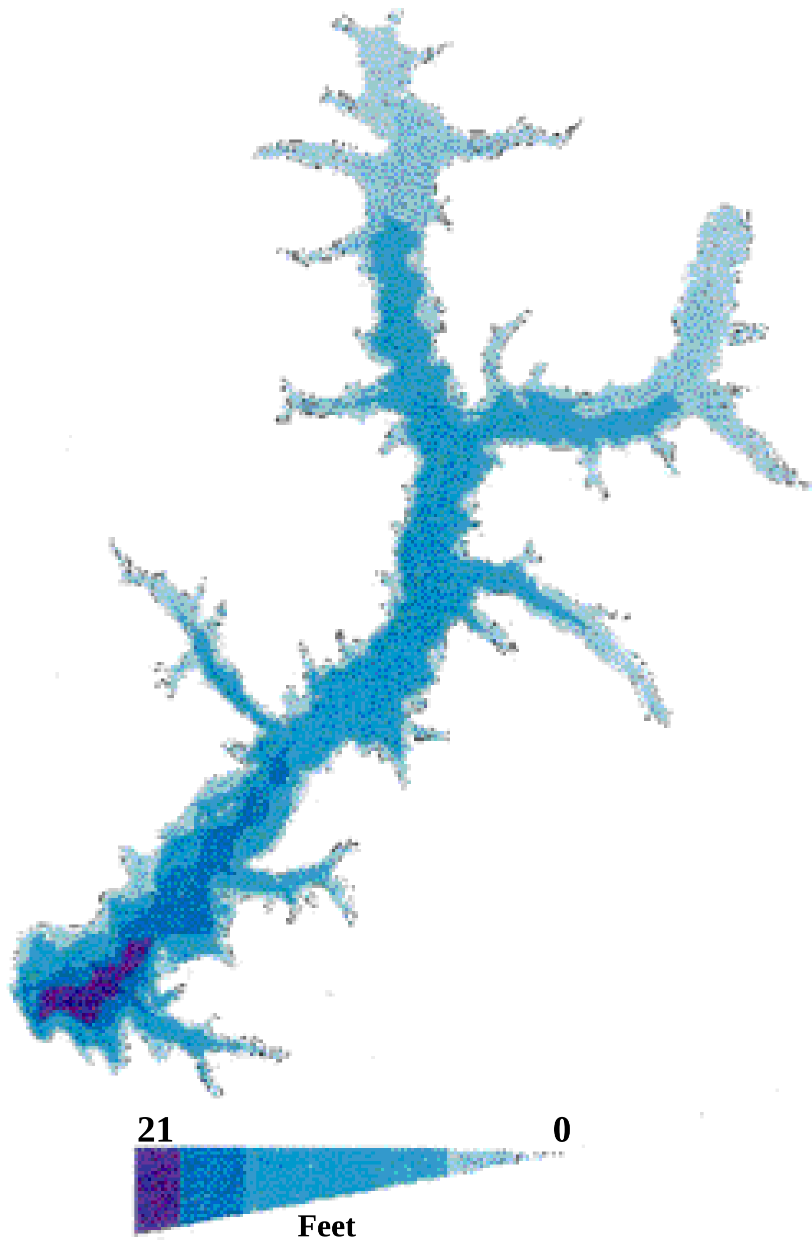
\+ Spot Depths

Depth (Ft)

0
10
19
34
39

Example Bathymetric Map

Washington Lake, Illinois
Bathymetric Map



Surface Area: 257 Acres
Mean Depth: 8 Feet
Volume: 2007 Acre Feet

Glossary of Terms

Areas-of-No-Significant-Sediment (ANuSS)	flatter parts of some watersheds that are more than 2000 feet from a concentrated flow water course, depressional or at least less than 2% in slope, and are not impacted directly by run-on water.
Bank Full	a term usually associated with a channel-forming flow of approximately a 1.5 year return. The within-channel indicators of this flow are used in assigning lateral recession rates and calculating total channel erosion.
Delivered Sediment	sediment produced by erosion in a watershed that actually reaches the outlet end of the watershed. This is generally only a small percentage of the entire sediment produced.
Diamicton	a general term for unsorted, unstratified rock debris composed of a wide range of particle sizes. Although no origin is implied with this term, most of the diamicton in Illinois is glacial till.
Drainage Density	an arbitrary term used to characterize stream dissection. Generally, it is the *feet* of channels (or miles) per square mile of watershed.
Drainage Texture	an arbitrary term used to characterize stream dissection. Generally, it is the *number* of channels per square mile of watershed.
Dynamic Equilibrium (for streams)	a concept that says changes can and do occur within stream systems in regard to erosion, sediment production, changes in shape and form of channels, etc., but these changes maintain an overall balance between in-flow and out-flow of materials and energy.
Ephemerals or Ephemeral Erosion	small channels formed as rills enlarge and coalesce into concentrated flow areas. These are small enough that they are generally destroyed each year with normal tillage operations.
FOTG	the NRCS Field Office Technical Guide, used by technically trained people to plan, apply and maintain appropriate conservation practices.
Geomorphic Unit (GU)	a rather arbitrary separation of landscapes into grouping based on similar soils, slopes, and expected rates of erosion and sedimentation.
Intermittent Streams	those watercourses that only have water present in them during the high flow times of the year, especially in the spring and fall. A few of these intermittent streams will have a flood plain associated with them.
Knickpoint	an overfall or abrupt break in the base of a channel that often times marks a change in geologic material or indicates a different erosion cycle.
Lateral Recession Rate (Annual)	the thickness of soil eroded from a gully or stream bank surface, perpendicular to the face, in an average year. Serve as the thickness component of the standard equation for volume of: Length x Height x Width (thickness) = Volume of soil eroded
Loess	windblown homogeneous dust that tends to form massive, unconsolidated but slightly coherent deposits. Originally deposited as the glaciers receded and water-laid glacial outwash was exposed to the drying action and energy of predominantly westerly winds. Loess blankets nearly the entire state in varying thicknesses and serves as a parent material for many of our present-day soils.

Parent Material	the geologic material in which our present day soils formed. Most common parent materials in Illinois are loess, glacial till, glacial outwash, alluvium, and bedrock residuum.
Perennial Streams	those watercourses that have water present in them during the entire year with only minor exceptions to this, for example for a few weeks in the summer. Some of these will have flood plains and some will not.
Physiographic Divisions	generalized geographic separations made in the state based on topography of the bedrock surface; extent of the several glaciations; differences in glacial morphology; differences in age of the uppermost deposits; height of the glacial plain above main lines of drainage; glaciofluvial aggradation of basin areas; and glaciolacustrine action.
Random Stratified Sampling	a method of sampling a watershed in which the target population (the total watershed) is divided into groups (GU's) called strata for the purpose of obtaining a better estimate of the mean for the entire population. Stratification involves the use of categorical variables to form groups that have similar natural resource concerns.
Sediment (aerated)	material deposited in a watershed that is subject to drying cycles. This allows the sediment to consolidate.
Sediment (submerged)	material deposited in a watershed through or within a body of water. Generally, these are not subject to drying and therefore does not consolidate.
Sediment Delivery Rate (SDR)	the percentage of erosion-produced sediment that is moved to the field edge and is ready for further movement, generally as part of a channel system. Varies for each type of erosion
Sediment Transport Factor (STF)	the percentage of sediment that the entire stream system will efficiently and effectively move through.
Sink	depositional area for sediment in a watershed. Can be small depressions within a watershed or the stream or lake (ultimate sink) at the watershed outlet.
Thalweg	the lowest or deepest points (channel) along a stream bed.
Till (glacial)	unsorted, unstratified rock debris composed of a wide variety of particle sizes that was deposited directly by or underneath a glacier. Often times contains the sand, gravel, and boulders that make up the bed load of many of our streams.
Top-of-Bank	understood to be the actual highest elevation of the stream bank. If the channel is not incised, top-of-bank and bankfull can be the same. Generally, this is not the case in Illinois.
Weathering	the process of physical disintegration and chemical decomposition in which rock and soil material change color, texture, composition, or form upon exposure to air and water.